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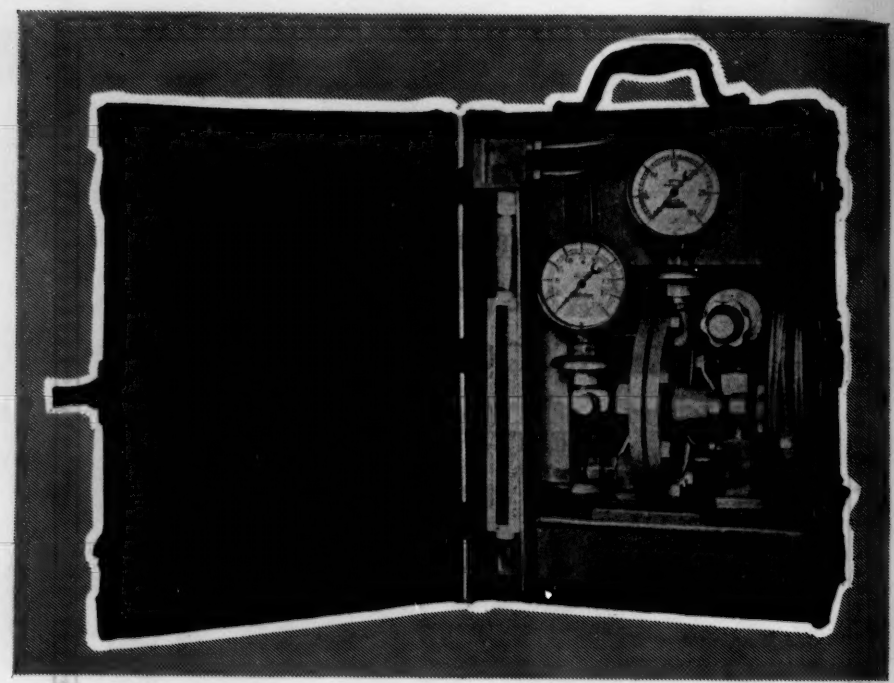

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RECENT PROGRESS IN THE ART OF WATER TREATMENT[1]

BY ABEL WOLMAN,[2] WELLINGTON DONALDSON[3] AND LINN H. ENSLOW[4]

The Chinese philosophers have always maintained that there is nothing new under the sun. There may be a new variant of an old idea, but if the question is pursued historically sufficiently carefully, one is likely to find that even the new application is only a revival of interest in an old method. In the field of water treatment, the tracing of new developments is even more complicated because of a terminology difficult to understand and sometimes in process of adjustment as new notions or new applications of old notions develop.

On this occasion, marking as it does an important milestone in the history of the American Water Works Association, it is appropriate to take stock of the developments in the art of water treatment during the past twenty-five or thirty years. In such stock taking our aim has been to avoid undue complexity and detail in describing new processes and new principles and to present in as simple terms as possible the practical significance of such advances in the art as have occurred in the past quarter of a century. In accomplishing this

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task, some omissions no doubt have been made, some failures to recognize priorities have occurred, some undue variation or emphasis on importance of contribution is likely to appear, but their excuse lies only in the desire to simplify scattered information for the most practical use possible. Extensive bibliographies have been intentionally omitted and undue references to responsible authorities have likewise been curtailed in order to conserve space.

MAJOR CHANGES IN THE DEMANDS UPON WATER TREATMENT

One interesting fact results from an historical review of the art of water treatment, namely, that whatever changes have occurred have been in variation of basic processes established a century or more ago. The artificially constructed slow sand filter unit at Chelsea, England, was in operation in 1829 and large scale use of the rapid sand filter with coagulants appears in the literature as early as 1885. Even the ubiquitous chlorine compounds were used for disinfection of water in 1902 in Belgium, 1905 in England and 1908 in this country. Public water supplies were softened by present day processes as far back as 1888 in England, 1890 in Canada and 1903 in this country.

Despite these early applications, however, steady progress in the art has occurred, a progress which has redounded to the advantage of the economy, health and comfort of the public. The outstanding characteristic, perhaps, of this progress has been in the changing emphasis placed upon the various attributes of quality of water. People were satisfied at one time with a water supply from which obvious suspended material was removed and it is surprising to discover how frequently even large amounts of turbidity were acceptable. As time progressed, the citizen demanded safety, in addition to clarity. Today, these demands have been multiplied manifold so that the water works operator must supply water that is clean, that is hygienically safe, that is tasteless and odorless, that will not destroy the distributing pipes in which it flows, that will make the life of the house-wife less difficult in laundry and domestic uses and that will supply the increasingly important demands of the industrial consumer. The motto of the twentieth century is "more and better water." How can this demand be met? It is this question that this paper attacks. Stripped of technical verbiage, what are the chances today of accomplishing the task more adequately, more cheaply and more safely than a quarter of a century ago? We shall trace the water through the available processes of treatment, in order to see

what the water purification man has done to make life easier, if not simpler, for the designer, the operator and the consumer. It is doubtful, of course, whether simplification has been the result. The refining processes now universally demanded by the public have to a considerable degree led to complexity rather than to simplicity of op eration.

PRELIMINARY SEDIMENTATION

Water has been settled to remove living and non-living materials for many centuries. Improvements in this art are primarily resident in changes in containers and in the development of mechanical devices for the removal of accumulated materials. The best recent examples are perhaps at the plants at Kansas City, Mo., and the new Howard Bend Works at St. Louis. Adequate settling of solids and rapid removal of their accumulations are important assets on especially turbid waters of the Missouri River type, even though, as at the Howard Bend Works, suspended matter may be added to already turbid water to promote coagulation and settling.

Interesting contrasts to these procedures are in use at Louisville, where sediment from preliminary sedimentation basins and from coagulation basins, is returned to the raw water when it is unusually clear. At Winnetka, Ill., ground brick clay is added by a dry feed machine to produce artificial turbidity.

COAGULATION

Aside from the rejuvenation of old coagulants and the development of new ones, the most important advance in this phase of the art of treatment is probably in the better understanding of the mechanism of coagulation, with the resulting economies and higher efficiencies attainable thereby. This conclusion appears to be valid when it is recalled that as early as 1903, William B. Bull used ferrous sulphate and lime coagulants at Quincy, Ill.; that, in 1911, he patented the application of ferric chloride, made from chlorine gas on scrap iron, to coagulation; that almost two decades ago excess alum coagulation and split coagulation were used at Springfield, Mass.; and that Hale advanced new hypotheses in 1913 to account for observed results on the coagulation of colored waters with alum.

Many of these empirical observations have been later confirmed when more adequate principles and tools were available for testing them.

Perhaps the earliest emphasis on the underlying mechanism of coagulation, with particular reference to the importance of hydrogen-ion concentration rather than alkalinity and to the significance of an iso-electric point for coagulation, was by Wolman and Hannan not quite ten years ago. These observations were important primarily in stimulating discussion and experimentation in the effort to clarify understanding of the coagulation process. That these efforts on the part of a great many workers were successful is attested by the fact that this particular process in treatment is now more scientifically and economically controlled than a decade ago. Much has been contributed to this understanding by the work of Buswell and Edwards in 1922, by Theriault and Clark in 1923, by Hatfield, and by Miller in 1924. To these investigations a number of the later developments in coagulation may be traced.

It is impossible to give a complete list of the modifications in and additions to coagulants which have appeared in less than ten years, beginning perhaps with the suggested application of sodium aluminate by Spencer and its gradually extended usage in the municipal and industrial field, either alone or in conjunction with filter alum. Although not universally applicable, it has found a field of importance where its use has been efficient and economical. At about the same time, Coe described a coagulant prepared from one part of soda ash and four parts of alum for use in softening processes. DeLaporte was perhaps the first to make practical use of this mixture. The aluminate is now available as a solid material for dry feed equipment. Powell and Christman in 1925 did much to determine the field of application of sodium aluminate with or without alum, and Hedgepeth not so long after showed its effectiveness in conjunction with ferric iron coagulants.

Following the studies by Mohlman and Palmer in 1926 with chlorinated copperas, by oxidation of ferrous sulphate solution with chlorine, in sewage sludge dewatering, Enslow and Hedgepeth in 1927 made their first application to the highly colored water at Elizabeth City, N. C., with unusually successful results. Beneficial results of high order have since been obtained at Chickasaw, Ala., Hertford, N. C., Mamaroneck, N. Y., Warren, R. I. and the Chicago experimental filtration plant. In this connection, it is important to point out, largely because it is in contradiction of textbook notations of past years, that the best coagulation of these highly colored waters with ferric compounds is at very low rather than at very high pH values.

This is likewise a desirable time to recall to this group that at the 1906 meeting of the American Water Works Association at Boston, the late Prof. George C. Whipple called attention to the "ferro-chlor" process developed by Dr. Duyk and used successfully as a coagulant at the Middlekerke, Belgium, plant, as early as 1902. Whether it was because of the excessive cost of this coagulant or for some other reason, the process has been quite completely ignored during the intervening twenty-five years. It now receives a new lease on life and probably will find its place in the armamentarium of the water plant operator. More recently Wilson at Los Angeles, California, has found ferric chloride the most effective coagulant for a colored well water supply at Wilmington, California. The work of Hopkins (1929), as to the value of trivalent iron in coagulation practice, should be given mention in this connection.

An interesting, albeit special, variant in coagulation practice, is Pirnie's procedure at West Palm Beach of pumping an alkaline [$Ca(HCO_2)$] well water into a soft surface supply to secure alkalinity and best pH conditions for coagulation.

In summary, therefore, the new processes in coagulation rest upon a foundation of better understanding of the mechanism of coagulation. Some of the newer coagulants come into use because their methods of production and consequent cost are lower than a decade ago. Their value is in supplying the water plant operator with a more varied choice of coagulating materials. The trend of their use is in the direction of complexity. All of which simply means that the better the understanding of this phase of water treatment, the more likely we are to develop processes of coagulation which will be specific for certain waters and which will be regulated with a higher degree of information and scientific understanding than has been the case in previous years.

CHLORINATION

Some of you may recall some five or six years ago the debate among sanitarians and water works operators as to where chlorine should be used and why. That debate has now shifted to the question as to where chlorine should not be used and why not. One of the remarkable developments in the field of water purification in the last ten years has been in the widening application of chlorine and its compounds for innumerable purposes. Revivals of application, increase in understanding of mechanism and empirical applications without

understanding, but frequently with good results, are the characteristics of the history of the use of this compound in water treatment. Over thirty years ago Sims Woodhead, in England, employed chlorine as a temporary expedient during a typhoid fever epidemic at Maidstone, England. Its use in ferro-chlor by Dr. Duyk has already been referred to. Perhaps the first large scale application of this compound to water disinfection was by Sir Alexander Houston in 1905 on the Lincoln plant of London. One of the most important contributions to sanitary science was thus made by Sir Alexander in providing for the City of London, through the expedient of chlorination, a water of hygienic safety for a quarter of a century.

The operations in 1908 at the Chicago stock yards and shortly thereafter at the Boonton, N. J. headworks of the Jersey City water supply, both by George A. Johnson, mark the first large scale introduction of this process in the United States. Of no less importance was the early qualitative use, for the detection of free chlorine, of ortho-tolidin by Earle B. Phelps, its subsequent study by Kinnicutt and F. W. Jones and its further quantitative extension by Ellms and Hauser in 1913. The vast importance of the orthotolidin test in the practical control of chlorination, however, was not fully emphazised until the chlorine control phases resident in the development of the residual chlorine determinations in Maryland were clarified by Wolman and Enslow during the period 1917 to 1919.

Real progress in the use of chlorine, however, dates from the initiation in 1910 of the use of liquid chlorine by Major Darnall of the United States Army Medical Corps at Fort Meyer, Virginia. Two years later, liquid chlorine was applied at the Niagara Falls, N. Y. municipal plant through an Ornstein solution feed equipment, developed with the assistance of Mr. Harry Huy, one of the distinguished members of this Association. From that time to this its application has been extended throughout the world, its control has been improved, its possibilities have been multiplied, its results have been recognized, and the understanding of its action only little increased.

Practically all of the extended applications of chlorine within the last ten years have resulted from the pressure placed by the public upon the water works operator to produce a drinking water which would be not only hygienically safe, but fit to drink from the comfort standpoint. Tastes and odors have been the blessing of the water works field, although many an operator would suggest the reverse

at the moment when the consumer is pestering him to the utmost on account of the objectionable tastes and odors in the supply. Although the blessing may have been one in disguise, the results of these demands by the public have been and are advantageous.

Originally the trouble from tastes and odors was blamed upon faulty chlorine dosage control. No doubt much of these difficulties, in the days of constant dosage of chlorine, may have been due to true excess or free chlorine. When a great many of these tastes and odors persisted, however, after careful control was introduced and residual chlorine tests were the standing practice in virtually all the plants in this country, it became necessary to search further for a remedy. The work of Race in 1917 at Ottawa, Canada, with chloramine, produced from ammonia water and bleaching powder, marks one of the first efforts to obtain a substitute for liquid chlorine or hypochlorite. Although the process did not find wide application, it still survives at Ottawa as a more economical and efficient procedure than the earlier bleaching powder process. In the same way prechlorination, that is, chlorination of raw water before application to the filter beds, was practiced for purposes of disinfection at Harrisburg, Pa. (1912) and by Powell at Avalon, Maryland, in 1910. Weston, however, used the plan as an aid to coagulation at Exeter, N. H. in 1914. In this field again, application was delayed considerably by the general tendency of water works people to withhold the use of new procedures until their value had been completely demonstrated.

Pre-chlorination, however, has resulted in the saving of many thousands of dollars in alum required for adequate coagulation. The experience of Howard at Toronto, Ontario, since 1921, and by workers elsewhere testify to this conclusion. The chief results of the procedure appear to be in more adequate algae control in basins and filters, lower bacteriological loadings on the filters, improvement in filter bed condition, reduction in wash water consumption, improvement in coagulation and a general over-all factor of safety in plant operation. Practical observations by Weston, Howard, Caird, Mangun, Watkins, Whitener, Cohen and Schoepfle, confirm these general conclusions.

Special mention should be made of the increasing application of chlorine to the control of algae growths, largely the result of studies by Hale in 1921. Practical use of chlorine for thispurpose has since been made at Mexia, Lufkin, and other plants in Texas, by Chester Cohen, at Kansas City, Kansas, by Mangun and more elaborate

observations by Hale in 1929 on the New York City water supply. Similar extensions of the use of chlorine have occurred in the industry, particularly in treating condenser water to eliminate so-called "slime" deposits, resulting in longer usage of condenser tubes and greater efficiency of heat transfer. Ice plants find the chemical useful to prevent the algae coating of cooling coils. Although this application is of recent date in this country, chlorination of condenser water has been used for a number of years in England. Similar slime growths in paper mills are now being controlled by the chlorination of water supply in re-circulated "white water."

THE CONTINUING STRUGGLE FOR THE PREVENTION OR CONTROL OF TASTES AND ODORS

Pre-ammoniation

Sir Alexander Houston, recognizing the superior advantages in some instances of chloramine, first suggested the application of ammonia prior to chlorine, in order to avoid tastes resulting from secondary reactions from chlorine with organic material. In America this was first demonstrated by McAmis at Greenville, Tennessee, and shortly thereafter by Spaulding at Springfield, Illinois. The elaborate investigations by Braidech in 1929 at Cleveland, Ohio, showed the value of the process as one of the most practical and economical measures for taste prevention. A number of months of plant operations since the initial experiments at Cleveland seemed to prove the pre-ammoniation is one of the very helpful deterrents to taste and odor production by chlorination. Detailed cost data and results obtained are presented at this meeting by J. W. Ellms. It is important to point out, however, that the cost of pre-ammoniation is reduced by some saving of chlorine. Whether or not it may be universally employed can only be tested empirically. The ammonia dosage required is generally 0.25 p.p.m. of ammonia or less. In addition to the places already mentioned the process is in use at Lancaster and Erie, Pennsylvania, at Cleveland, Warren, Defiance and East Liverpool, Ohio, Mamaroneck, New York, at the Hyattsville plant of the Washington Suburban Sanitary District, Md. and at Burlington, New Jersey.

Most recently, the use of the ammonia-chlorine process at Greenville, Pa., has shown an apparently more effective control of algae than had been previously secured with either copper sulphate or chlorine alone.

Ammonia has been successfully used in 1930 at Montebello Filters, Baltimore, for overcoming taste in the water, due to the combination of chlorine with the essential oils released from microorganisms, principally, Asterionella and Fragilaria.

Ammonia is applied to the water as it enters the mixing basin, and chlorine as it leaves. The resultant chloramines have had the effect of retarding the action of the chlorine to such an extent, that a residual of 0.1 p.p.m. is now maintained on water applied to the filters, a thing not possible before ammonia was used.

The increased residual chlorine in the water passing through the filters has apparently had the effect of inhibiting to a considerable extent the growth of bacteria and organisms in the filter beds, and there has been much less trouble than formerly with the matting of filter sand.

Permanganization

Again the water works profession is indebted to Sir Alexander Houston for the development of another process of taste prevention or destruction with permanganate, through his work in 1925 and 1926. As far as we can discover James N. Caird was the first worker in America to use potassium permanganate with success in taste elimination or prevention. In 1929, Harrison at Bay City, Michigan, applied permanganate to the raw water in sufficient quantities to carry the pink color of the permanganate through the mixing chambers. In 1930, Rosenthal made use of the same process in the Dallas, Texas, raw water, also with some degree of taste improvement. In this instance, too, wider application of this chemical has been delayed either because of the fear of manganese troubles or the cost of permanganate. Those who have used the process have had considerable success and some prefer it to ammonia treatment. Observation appears to indicate that waters of high dissolved organic content contributed by industrial wastes or decayed vegetation are somewhat more amenable to permanganate treatment than to ammoniation. Waters, on the other hand, containing only small amounts of the end products of decayed vegetation or organic industrial wastes are amenable to preammoniation. In some instances permanganate has aided coagulation, apparently due to the "flocking out" of manganese with alum or iron. It should be recalled, furthermore, that permanganate has the power of reducing or destroying tastes already present, whereas preammoniation primarily prevents taste production.

At the present writing permanganate has been used at intervals at about ten plants in America, in quantities varying from 0.04 to 1.0 p.p.m. The plants include Bay City, Michigan; Dallas, Texas; Rensselaer, New York; Roanoke, Virginia; Western New York Water Company at Lackawanna, New York; Rochester and Lake Ontario Water Company at Rochester, New York; Newberry, South Carolina; Mamaroneck, New York; and East Chicago, Indiana.

Super and de-chlorination

Both Adams and Houston experimented successfully with super and de-chlorination in 1924 and 1925. Under the guidance of Norman J. Howard, super-chlorination and de-chlorination with sulphur dioxide gas were started in Toronto, Ontario, in 1926. Since 1927, it has been used continuously and on a large scale to prevent tastes in the Toronto, supply whenever the wind blows pollution from the harbor out to the intake in Lake Ontario. The process has attracted international interest and apparently has proven successful, not only at Toronto, but elsewhere. Under the supervision of Hale it has recently been used at Jamaica, New York, with success and is being reported upon at this session.

Activated carbon filtration

Great progress in the study of tastes and odor elimination by filtration through beds of activated carbon has been made in America within the last two years. Many years ago, however, charcoal beds were employed abroad and the use of activated carbon in conjunction with sand filters was introduced in England decades ago by the Candy Filter Company of England. Perhaps the most extensive studies of activated carbons in this country have been those made by Baylis. Additional observations have been made by Behrman, Weston and Norcom and G. R. Spaulding. Many of the conclusions on the effect of activated and other carbons as de-chlorinating agents in relation to carbon quality and size, rate of filtration and so on, are to be presented at this meeting.

Baylis first demonstrated on a small scale the remarkable properties possessed by certain activated carbons, particularly a commercial brand known as "Hydrodarco," in removing chlorine and by-product tastes. Apparently it is desirable to superchlorinate the water and remove the chlorine excess by activated carbon rather than to depend upon the by-product taste compounds being removed continuously.

with the risk of some of these tastes passing through the filter. The excess chlorine aids somewhat in keeping the carbon activated.

From present available data a "Hydrodarco" carbon filter bed, 24-inches deep, will remove between 1 and 1.5 p.p.m. residual chlorine continuously for eleven months or more, before re-activation becomes necessary, that is, before enough free chlorine passes through the bed to be objectionable. These findings give a surprisingly long period of service for a carbon bed which was operated at a rate of 2 gallons per square foot per minute.

To date there is no record of a municipal carbon filter installation in America. There are one or two in Germany of recent installation. They have been entirely successful and the filters have required regeneration about every three months by steaming out. Important experimental observations have been published in Germany by Imhoff and Sierp (1929) and by Sartorius and Ottemeyer (1929).

There are, however, in the United States, a number of bottling plants which have used successfully activated carbon filters. Food products establishments are installing them and one hospital is on record as intending to super-chlorinate and de-chlorinate its water supply by this method to produce a sterile water supply for the building.

The process should possess a particular appeal to the smaller municipalities, which may not have careful supervision of chlorine treatment of the public supply. In such instances some overdosage could be the usual procedure, with removal by carbon filtration of excess chlorine and resulting taste compounds after relatively short contact with the chlorine. Improved palatability of the water should result.

CORRECTION OF CORROSION DIFFICULTIES

In this field as in others, great progress has been made in the last ten years in making use of knowledge which in some instances was available a number of years prior. Again application of known principles and the development of new techniques wait upon public demand. When this demand becomes insistent enough old procedures are re-discovered and new ones are added. Some twenty years ago D. D. Jackson used soda-ash to correct corrosion troubles at Long Beach, Long Island. Tillmans, many years ago, studied the mechanism of corrosion and pointed out the importance of dissolved oxygen, carbon dioxide, and hydrogen-ion concentration. In 1912,

Hale made extensive studies on the importance of dissolved oxygen in corrosion and of the secondary importance of carbon dioxide. He reported upon his findings in the *American Journal of Public Health* in 1913, Vol. 3, page 1337.

The first use of sodium silicate in a municipal supply in this country was in 1923 by Weston, to correct difficulties with corrosion of lead pipes. Speller's work in 1923 deserves special mention as clarifying the mechanism of pipe corrosion and suggesting means for correction. His comments on the importance of dissolved oxygen and pH and of the effect of temperature and velocity of flow through the pipes have done much to make more intelligent the control of this problem. Scientific application of chemicals to prevent corrosion was made in the addition of lime to the filtered water at Baltimore by Baylis, by Hechmer at Hyattsville, Maryland, and at Norfolk, Virginia, by Watkins, with even earlier use of the same principle by Whipple and Donaldson, operating individually. About the same time the use of caustic soda for this purpose was introduced at Charleston, South Carolina and at the West Virginia Pulp and Paper Company plant at Luke, Maryland.

More extensive studies were carried out in New York by Hale in 1928, in order to determine the effect of various chemicals in the prevention of corrosion on steel, brass, lead and wrought iron pipes. In his studies, soda ash, silicate and lime, under hot and cold water conditions, were employed.

In general, corrosion difficulties in many instances may now be corrected with economy. Better understanding of the chemical balance of the water supply necessary to avoid corrosion is now at hand. A convenient index of the probability of corrosion is afforded by the dissolved oxygen reduction in portions of the distribution system. Elimination of carbon dioxide by aeration or by the application of chemicals or by both is a practicable procedure. The establishment of a chemical balance adequate to protect distribution pipes is frequently feasible. No longer is it necessary in many instances to distribute a water through a distribution system with resulting destruction of the pipe carrying the water.

Convenient and simple tests for determining such equilibrium or chemical balances have been used by Baylis, by means of which it is possible to determine easily whether water delivered to consumers is saturated, supersaturated or undersaturated with calcium carbonate. This is done by adding calcium carbonate to the water in

excess. If the water is undersaturated, the alkalinity will increase; if saturated, it will remain constant; if supersaturated, it will decrease. Water that is supersaturated with calcium carbonate will deposit a coating on the insides of pipes, and if continued too long the pipes will become clogged. On the other hand understaurated water may cause corrosion. Linschoten in Holland has recently (1929) devised a useful chart for correlating aggressivity, carbon dioxide, pH and alkalinity.

WATER SOFTENING

The American public has been slow in taking advantage of knowledge existing for almost a century as to how to reduce the soap consuming constituents of the water supply. A process for softening water was invented by Clark, a Scotch chemist, in 1841. Progress in the introduction of the process, however, has been very slow, apparently due to lack of understanding on the part of the public, both as to the needs for softening and as to the available economical procedures. One of the first municipal plants installed in America was in 1901 at Winnipeg, Manitoba, where as early as 1903 re-carbonization using carbon dioxide from burning coke was developed and applied by J. O. Handy, then chief chemist of the Pittsburgh Testing Laboratories.

The first municipal softening plant in the United States apparently was at Oberlin, Ohio, and was placed in operation in 1903. Although the excess lime treatment had been previously used in industrial and railroad water softening practice, the first application to municipal softening practice was made by C. P. Hoover at Columbus, Ohio, in 1908. The process resulted in softening water and in higher bacterial reduction, with the use of re-carbonation. The value of the excess lime treatment was first pointed out by Sir Alexander Houston. In 1918, Youngstown, Ohio, began the use of excess lime, in this instance, however, for the definite purpose of increasing the bacterial destruction and in order to avoid the use of chlorine on a water containing a number of industrial wastes of taste producing character.

The first municipal use in this country of re-carbonation, that is, the application of carbon dioxide to a water chemically softened in order to avoid the deposition of lime products in filter beds, distribution lines and service pipes, was at Owensboro, Kentucky, in 1912. Interest in this process lagged, however, until about 1921 when C. P. Hoover gave additional emphasis to its value. The first large scale

application of the process was at Defiance, Ohio, at about this same time.

A similar revival of interest has occurred in the use of the zeolite process which was recognized and patented in England in 1896. Apparently zeolite material was first artificially produced in America by Gans in the form of "permutit" in 1913.

Zeolite is sodium aluminum silicate, but becomes calcium magnesium aluminum silicate after hard water is passed through it. It may then be regenerated or reverted to sodium aluminum silicate by backwashing it with a solution of common salt (NaCl). The hardness of water when passed through active zeolite softeners at proper rates is reduced to practically zero.

Although it was used until recently primarily in industrial plants, within the last two or three years considerable interest has been created in its application to large municipal plants. Installations within the past two years have been made at the municipal plants at Sewickley, Pennsylvania and at the Ohio Valley Water Company plant near Pittsburgh, Pennsylvania. The advantages of the process appear to be in the simplicity of control due to the fact that only one chemical is needed, common salt; changes in hardness of raw water do not require manipulation and control on the part of the operator and there is no sludge. On the other hand, the water passing through a zeolite softener must be clear and softened water contains residual sodium bicarbonate which in some instances may create difficulty.

An interesting variation of the use of the zeolite principle is at the Bremen, Ohio, plant, where both ferric and ferrous iron are removed from the water, in addition to producing a reduction in hardness.

C. P. Hoover has within the past year made another important contribution to the practice of water softening in pointing out the advantage of using return sludge in the water softening process. By this plan he has succeeded in reducing the carbonate hardness of all types of water and under all temperature conditions to almost the theoretical limit of solubility, that is, to less than 20 p.p.m. This accomplishment is of great practical importance, inasmuch as until recently an average reduction of carbonate hardness to 50 or 60 p.p.m. was considered excellent, with many softened waters frequently producing 85 to 95 p.p.m. of hardness after softening.

Perhaps the outstanding feature of importance in the water softening field is the neglect of the general public in insisting upon its wider use. Buswell has recently pointed out that in Illinois every

public supply should be treated for the removal of hardness and yet in that state only one percent of the municipalities have water softening plants. Probably not over ten percent of the water supplies in this country which should be softened are subjected to that treatment. The economic waste due to this fact is great. Simple and economical processes are available. Why are they not used?

IRON AND MANGANESE REMOVAL

The recognition of the importance of removing minute quantities of manganese in waters is relatively of recent origin. The removal of iron, however, has been given a great deal of attention in the past, although the number of installations is still small. Practically all the earlier installations depended upon aeration and filtration through contact beds of gravel, charcoal or cinders for the deposition and removal of iron and manganese. Weston was one of the pioneers in the development of these processes. Pirnie in 1923 pointed out that excessive aeration was undesirable and that contact beds of gravel with upward flow give satisfactory iron removal results. Installations of this character are in use since that time at Long Beach, New York, Stuart and Punta Gorda, Florida. The recent exhaustive studies in iron and manganese removal by Tillmans and his co-workers should be recorded.

In 1924, Baylis added to the knowledge of manganese removal by his studies at Baltimore, where he found that increased pH, accompanied by the addition of lime and iron in coagulation, proved more effective in the removal of maganese than by the use of alum. Prechlorination apparently was also helpful. The experimental observations by Donaldson at Memphis, Tennessee, in 1921, have established quantitative standards for the removal of dissolved gasses by aeration and by contact coke beds in trays.

Kuhr's observations on biological aspects of manganese removal in Holland in 1927, although still controversial, have added to the interest in this problem. His studies on the effect of manganic oxide in absorbing manganates from superchlorinated water by contact with manganese dioxide are of great interest.

Practical control of manganese deposits and manganese mud balls in filters has been accomplished by Derby in 1928 at Beverly Hills, California, by superchlorination of the beds and twelve hours standing at intervals. Hale's observation (1928) on the efficacy of chlorination in removing and controlling manganese accumulation in New York City's aqueducts deserves mention.

DEVELOPMENT IN ANALYTICAL METHODS AND LABORATORY CONTROL

A summary of the contributions in this field is by no means simple, largely due to the fact that many of the procedures are still under discussion, some are under attack and some have limited application. It is useful, however, to refer to the more important of these procedures for purposes of record. This is particularly desirable in view of the extensive operations during the past five years of Committee No. 1 of this Association which deals with standard methods of analyses.

The studies in 1926 by Buswell and Boruff on ortho-tolidin and starch iodide methods for residual chlorine determination have been of great practical importance. Enslow and Tiedeman have made similar observations.

In the field of boiler water analysis the development by Bardwell in 1926 of a rapid method for determining various types of hardness in boiler water has facilitated industrial and railroad water softening control to a considerable extent.

Since 1928, important contributions in this field may be summarized as follows:

a. The development of an important and accurate method for phenol determination by Gibbs and its modification by Baylis for application in the sanitary field. The method of Donaldson and Furman was the most useful phenol test available for some years prior to the Gibbs' procedure.

b. The procedure for bio-chemical oxygen demand determination has been much more carefully studied and accordingly improved under the leadership of Mohlman in this country and Sierp in Germany.

c. Considerable emphasis has been placed upon improving the methods of detection of the B. coli group of organisms. The development by Salle and Noble of direct plate methods for growing and counting B. coli, although still in an experimental stage, is of great importance in pointing the way to future simplification of bacteriological water examination. Extensive work on selective dyes by Jordan, Hale, McCrady, Levine, Dunham, Howard, Thompson and other workers should lead in the near future to practical and valuable changes in standard tests for the B. coli group.

d. An improved method for estimating manganese has been proposed by Forman, in which manganese is oxidized in alkaline solution and ortho-tolidin is employed to produce a yellow color which may be compared with standards.

e. Improved methods of measurement of suspended matter in water are being studied by Baylis.

Of general importance in this field has been the development in 1917 of the eosin-methylene-blue plate method for identification of B. coli by Max Levine; the preparation and commercial development in 1921 of convenient pH standards; the preparation of standardized and economical dehydrated culture media in 1923; the development in 1924 by Hale of an electrolytic, colorimetric and volumetric determination of copper in water; improved methods of determination of iodine in water by McClendon, Clark, Daniels and others in 1926; quantitative studies of phenols in water by Donaldson and Furman; the use of chlorine demand of a water as an indicator of organic content by Froboese in 1920, Keiser in 1926 and Meadow and Hale in 1927; the development of the ortho-tolidin methods for dissolved oxygen determination by McCrumb and others in 1929; and the development of a technique for measuring hydrogen sulphide by Salle and Reinke in 1929 by the use of antimony sulphide with chlorimetric comparison with standards.

STEEL TRUNK LINES WITH BELL AND SPIGOT JOINTS[1]

By Wm. W. Hurlbut[2]

The use of steel pipe with bell and spigot joints was initiated in Los Angeles during the summer of 1905, when 2½ miles of 16-, 20-, and 24-inch diameter riveted steel bell and spigot pipe were installed. This pipe was fabricated in 24 foot lengths, from $\frac{3}{16}$-inch thickness of plate, and the bells made from plate ½-inch in thickness and riveted to the pipe. The pipe was dipped in asphaltum and the line is operating at the present time under 90 pounds pressure. It was laid with cement joints to control electrolytic action, and after twenty-five years of service it shows no deterioration.

Bell and spigot welded steel pipe was first used by the City of Los Angeles during the year 1916, and during 1916 and 1917 over 100 miles of 8-, 12- and 16-inch bell and spigot welded Matheson joint pipe was laid. This pipe was installed in the San Fernando Valley, in areas where adverse soil conditions existed, and is operating under heads varying from 100 to 500 feet. This pipe was all laid with cement joints. At the present time there are 395 miles of small diameter bell and spigot welded steel pipe and 55 miles of large diameter bell and spigot welded steel pipe in the system which may be termed as trunk lines.

In a city with the varying topography Los Angeles has, where water is served from sea level to 1400 feet above sea level, it has been necessary under the conditions of service to build trunk lines of steel, due to the fact that it is necessary to carry excessive pressures on these lines and step down the pressure at the various points of supply into distribution reservoirs and the connecting system.

The advantage of the bell and spigot steel welded pipe for trunk lines over that of the riveted steel line is twofold:

[1] Presented before the St. Louis Convention, June 4, 1930.

[2] Water Distribution Engineer, Department of Water and Power, Los Angeles, Calif.

There is no possibility of a leak in the bell and spigot line, except at the bell joint, while in the case of the riveted line you are depending to a large extent on the riveting and caulking, together with the degree of tightness resultant from a proper protective dip.

The saving in cost of a 24-inch bell and spigot welded steel trunk line laid with cement joints as against the same diameter of a riveted steel trunk line with field riveted girth joints will vary, according to our experience, from $1.00 to $2.00 a foot. The cement joints as used on the water works in Los Angeles are neat cement with 17 to 19 per cent of water by weight, thoroughly mixed, resulting in a compound that is thoroughly moist, and when taken in the hand and squeezed no moisture will appear in the hand or between the fingers. This cement is driven into place with caulking tools by hand, and one man, under average conditions can make a joint in a 24-inch line in fifteen minutes.

The pipe as laid in this Department is approximately in 24 foot lengths, there being only one bell hole to every 24 feet of trench. In the case of field welded girth joints, the same conditions exist as in the case of the bell and spigot joints, however, more room is required in the bell holes to make the welded joints, and the cost of the welded joints approaches that of the riveted joints. Furthermore, it is necessary to provide expansion joints at least every 300 feet to take care of the expansion and contraction, due to temperature stresses while this pipe is exposed to the rays of the sun and the coolness of night during installation, and even with the greatest of care, experience has shown us that at least 10 percent of the welded field joints will pull after the line is backfilled and put into service.

Two miles of 24-inch bell and spigot line recently installed was laid with cement joints with the exception of 1,000 feet, which was laid in water bearing ground, through which the joints were poured with lead, the same practice as used in cast iron pipe lead joints. There was not a single joint that leaked throughout this entire line, which is operated under a head of 180 pounds pressure.

The method of testing a line of this nature is to backfill with sufficient cover to equalize temperature stresses between control gates, so that the line can be tested out and all joints inspected with full head, before permanent backfilling and street resurfacing is placed.

On this particular line, the portion laid in the ground water where conditions were bad, precaution was taken to apply the proper protective coating to insure the life of the pipe and minimize corro-

sion. Bitumastic enamel was used for this purpose. It was applied locally at the trenchside by the Department.

The standard as adopted for bell and spigot welded steel pipe as used by the City of Los Angeles for diameters of 24-inch and larger, is a minimum thickness of $\frac{3}{8}$-inch for the shell of the pipe, and $\frac{3}{4}$-inch for the bell. The reasons for this thickness of plate are:

1. It is absolutely necessary that the pipe shall conform to a true circle, both at the spigot end and the bell end, as without obtaining this condition it would be impossible to avoid cracks in the cement joints after the pipe was put under pressure.

2. The increased thickness of metal over the required thickness that would ordinarily be used, governed by the factor of a safe working head, is allowed for the increased life of the pipe.

3. Any minor settlements that might have the tendency to distort the pipe in the trench are safeguarded by this additional thickness.

The bell and spigot joint steel pipe has the same advantages over the riveted or the welded joint pipe that the bell and spigot cast iron has, namely, it is possible to effect the ordinary deflection in the joint that may be encountered in the installation of the line, due to substructure interference or the alignment itself, also the flexibility of the joints under ordinary conditions of installation and operation, as against the stiffness of the riveted or welded joint.

The type of welded steel bell and spigot pipe that predominates in the system is the hammer and lap welded pipe, although in the past few years several miles of 20- to 40-inch diameter automatically longitudinally electric welded bell and spigot steel pipe, fabricated in the local shops, has been installed with satisfactory results.

On this particular pipe the bell has a caulking depth of $4\frac{1}{2}$-inches, and the caulking space at the middle section of the bell is $\frac{3}{4}$-inch, tapered to $\frac{1}{2}$-inch at the end of the bell, and the spigot end of the pipe is flanged, not to exceed 45°, in order to provide a bead for the same purpose as the bead on cast iron pipe, to prevent the caulking material from being forced into the pipe.

Sufficient experiments are lacking to determine definitely the factor C according to the Hazen and Williams formula, for welded steel pipe. However, it is only fair to assume that the conditions in the use of welded steel bell and spigot pipe follow fairly closely those of cast iron pipe. Experiments seem to indicate that in heavily riveted pipe the average value of C for any age is the same as for cast iron pipe of twenty years greater age, and for light riveted pipe of any age, is the same as that of cast iron pipe ten years older.

With the above facts it is safe to base a comparison and it may be assumed that a welded steel pipe will carry from 7 to 19 percent more water than the riveted steel pipe of the same diameter, the average flow between these limits depending upon whether the riveting is light or heavy.

As a conclusion, with all the foregoing facts reviewed, it is safe to state that the bell and spigot welded steel pipe effects an economy as to cost of installation and maintenance, has an increased carrying capacity over corresponding diameter of other types of steel pipe, and when laid with cement joints, minimizes electrolysis. The same crews and methods used for cast iron pipe are standard for the bell and spigot welded steel pipe.

DISCUSSION

GEORGE W. PRACY:[3] The men of the Los Angeles Water Department have pioneered on so many improvements in water works practice that anything they do is watched with interest. Their work in serving their immense territory has given them an extensive experience in the design of large trunk lines.

The selection of the proper joint to use in a steel trunk line is a problem that will probably always confront the engineer. Conditions vary and construction must meet the conditions existing on each job. Costs must be studied for each job, the object being to get a pipe line that will give the least annual cost rather than the least first cost. The material to be used, method of manufacture, pipe coating, minimum thickness of plate, and type of field joints all enter into the problem. Local conditions control all such design.

The use of cement in the joints is quite a factor in preventing electrolysis. In San Francisco a series of cement joints, usually three, is put into the line on either side of car tracks, and at other places where it seems likely that stray currents might get on to the pipe.

The bell and spigot joints undoubtedly give a flexibility to the line and act as expansion joints.

Our practice in San Francisco differs somewhat from that of Los Angeles. Our steel pipe lines have been in general designed with a factor of safety of four to which is added not more than $\frac{1}{16}$-inch to allow for corrosion. Our minimum thickness of metal for 24- and 30-inch pipes is $\frac{3}{16}$-inch. Our recent 44- and 54- inch pipes have a minimum

[3] Water Department, San Francisco, Calif.

plate thickness of $\frac{1}{4}$-inch. We have only one expansion joint in our system, that being where a 44- and 60-inch pipe join at right angles, both pipes being on trestle.

For the past several years the steel pipe laid in our city system has been welded, both in the shop and field. We have had no trouble with our welds. It must be remembered that these welds were mostly of plates $\frac{3}{16}$-inch thick with none more than $\frac{1}{4}$-inch thick. Our pipe has all been dipped and, of late, wrapped before leaving the shop.

While our practice has met our conditions we are glad to see other methods tried by neighboring communities so that we can profit by their experience.

F. M. RANDLETT:[4] The author of this paper has given expression to facts, pertaining to this type of construction, which have been under his observation and the conclusions, as to its advantages under the conditions named, are valuable.

If this paper is read by those who do not live on the Pacific Coast, it may seem unusual that the use of neat cement joints is emphasized so greatly. The successful use of cement joints all along the Pacific Coast for cast iron pipe and the results apparently obtained by the City of Los Angeles for steel bell and spigot pipe would seem to be conclusive as to the efficiency of this type of joint. This paper, however, does not imply that other kinds of material or types of joint under different conditions would not be economical and better.

We quite often hear of adverse opinions in regard to any type of construction, but it would seem that the advantages as set forth by Mr. Hurlbut successfully answer such opinions for similar conditions.

To quote from page 67 of the 1921 report of the American Committee on Electrolysis pertaining to cement joints, it says, "Cement joints have long been used on gas mains and have been known to preserve a high resistance over a long period of time and, if used in sufficient number, they are effective in preventing the flow of stray currents on pipe lines." This confirms Mr. Hurlbut's conclusions as to this feature.

The field equipment required for making up cement joints on this type of pipe is of course less than that required for welded, riveted or other jointing material. That is, lead furnaces, air compressors and tools or welding outfits are of course superfluous.

[4] Pacific Coast Manager, Robert W. Hunt Company, San Francisco, Calif.

A careful investigation of breaks in trunk lines will probably show that most pipe line breaks are due to some external force set up by improper laying or movement outside of the pipe itself. Few trunk lines, when properly designed for the pressure they are expected to carry, have failed because of the internal hydrostatic pressure. Therefore, a type of pipe that will allow a reasonable degree of flexibility and can lend itself to some variation of alignment during construction and while in service, certainly has advantages.

From Mr. Hurlbut's paper, it is assumed that this type of construction has proven economical, both as to first cost and maintenance. This, however, does not indicate that a similar type of construction would prove equally advantageous under all conditions.

A study should be made, always taking into account the soil conditions, character of water, alignment and location of pipe, before it could be definitely decided that the material and type of construction set forth would be the most economical, figured on an annual cost basis.

Protection against internal and external corrosion on steel pipe, of this or any other type, is a matter for special investigation, depending on the locality and conditions. And this feature must of course be given consideration in estimating first and annual costs.

It would be interesting if Mr. Hurlbut could some time show the total annual cost of a trunk line of this type, as compared with other types and material; particularly, if they have them in use in the same locality or under similar conditions.

It is this annual cost that should interest us most, instead of the first cost at time of installation, and it is the absence of records showing interest, and sinking fund requirements, maintenance or repairs and operating costs of one type of construction as compared with another under like conditions, that may often result in the selection of an uneconomical program of construction.

Matheson joint bell and spigot steel pipe has been manufactured for many years and possibly some one may offer us statistics covering these features of economic selection.

WM. W. BRUSH:[5] In New York, we are very much interested in the question of joints for steel pipe. We use steel pipe from 30-inch diameter upward, and our practice is to use $\frac{1}{2}$-inch plate. In that regard we follow more closely Los Angeles than San Francisco's

[5] Chief Engineer, Department of Water Supply, Gas and Electricity, New York, N. Y.

practice. Our field joints are riveted and our longitudinal joints may be the welded or lock bar type or riveted. We have had each one of these types of joints adopted by the contractor in the last four or five years. We leave it to the contractor to say which form of joint he desires to use.

What I am especially interested in in this paper is the question of electrolysis. For the many years that I have been connected with the City Water Department in New York, there has been very little difficulty due to electrolysis until the last four or five years. We had one very serious example of electrolysis, which was due to another city department operating a broken down trolley system and not reasonably bonding the return, so that we could not blame anybody except the City. We could not get the City to correct the condition until the pipe line was in rather bad shape. We welded the pits, welding 25,000 of them in a distance of about 800 feet, and there were a total of about 40,000, but the remaining 15,000 were not deep enough to justify welding. We now have at least two locations where the steel pipe lines are being affected detrimentally by electrolysis, and we have a corps of men authorized and about to be organized to take up an intensive study of the electrical conditions that are affecting the pipe lines. I would not be at all surprised to see the cement joint used to some extent in our steel pipe lines in the future.

J. W. Ledoux:[6] Mr. Chairman, I may mention a small instance that will be of interest. In 1893 or 1894 we built a distributing reservoir, which among other things provided a masonry gate house, the basement of which contained an elaborate system of cast iron pipe and fittings and screen pots to take care of the supply in three directions.

We decided to use bell and spigot joints, and instead of using lead used natural cement mortar (one to one, according to my memory) tamped into the joints as dry as practicable. We would have used Portland cement, but in those days Portland cement was very expensive and difficult to obtain.

Recently, these joints were examined in the bottom of the gate house and found to be in perfect condition.

In connection with the same system of water works we had occasion to lay 1,000 feet of 18-inch vitrified pipe through very wet

[6] Consulting Engineer, Philadelphia Pa.

ground, and at that season of the year it was difficult to free the trench, which was about 4 feet deep, of water. Instead of neat cement mortar we used neat cement with North Carolina tar, after experimenting with this and finding that the strength of the mortar was about the same as if we used water. This was made up in the consistency of rather soft putty and forced into the joints, in some places under 2 feet of water. The joints stood very well; in fact, as good as if they were made with cement and water; and this practice was adopted successfully thereafter, wherever we had troublesome cases of that kind.

GEORGE H. FENKELL:[7] During the past few years, a considerable amount of steel pipe has been used in Detroit, following about the same practice as used in New York in determining the thickness of the shell. The minimum thickness of the plate is ½-inch. In the beginning, the riveted pipe was used, and a considerable quantity of Lock Bar pipe. More recently a considerable amount of welded pipe has been used. The general practice has been to use riveted curves, Ts, and specials. I think in only one case have welded curves been used. Generally the roundabout seams have been riveted. The bumped joints, as manufactured by the National Tube Company, have been used to some extent, and have proven very satisfactory for us in tunnels. It becomes desirable at times to lay large steel pipe through tunnels under railroad tracks or under bodies of water, and the bump joint can be joined together easily in rather limited space. No extended experience in Detroit has been had with roundabout welded seams, but recently about 9000 feet of 54-inch Armco plate pipe with welded roundabout shop seams has been laid. Generally, with the necessity to make what may be considered a patch or an alteration, it has been done by riveting. There seems to be no standard practice for dipping steel pipe. There are a number of dips on the market, but just how satisfactory these will prove relatively has not been determined, because steel pipe has not been used in Detroit long enough to really determine this feature of construction.

A. O. DOANE:[8] On the Metropolitan Water Works in Boston, there has been trouble almost since they started with electrolysis. We laid cast iron pipe exclusively for many years and one 48-inch

[7] Manager and Chief Engineer, Bureau of Water Supply, Detroit, Mich.
[8] Metropolitan Water Board, Boston, Mass.

line was so badly affected part of it had to be relaid, which was done at the expense of the street railroad company, and another 12-inch line was also partially relaid. That was rather expensive for the railroad company, so they took measures to bond their tracks properly, and in general have them improved so that there has been no serious trouble for a good many years, but there are still stray currents. In experimenting with various types of installation joints, we tried rubber. That did not seem to work out well. Then we tried a wood joint, with turned soft pine staves driven into the bell, and wood ring at bottom of the bell. That did pretty well, but the staves had some tendency to come out, and an iron band was put on in front of them. Of late years we have put the wood ring in just the same, but substituted some of the joint compounds of the sulphur base type. That seems to give satisfactory protection if the joints are located with due regard to electrical and soil conditions. These devices have reduced the amount of current flowing on the lines so much that there does not seem to be any serious trouble from electrolysis now.

In a steel line, it has been the practice to put in some cast iron bell and spigot pipe, as part of the line, to put the compound in. We have not as yet tried any steel bells. Gauging stations are established on the main lines, which are periodically gone over to see if any current is flowing, and if so, how much and in what direction, etc. Of course, the trouble occurs where the current leaves the pipe, not where it gets on it.

We have laid a considerable amount of steel pipe from 60 to 30-inch in diameter with longitudinal joints electrically welded by automatic machines of the carbon arc or metallic arc type. The circular field joints are riveted as it is difficult to weld these satisfactorily in large diameter pipe. Field joints in gas and oil pipe lines up to 20- or even 24-inches in diameter are now successfully welded and it is probable that circular joints in larger pipe may be welded by improved methods

MR. TRUMAN (Colorado Springs, Colorado): I just want to ask a question if it is the general practice to have the steel pipe galvanized dipped or dipped only?

CHAIRMAN BRUSH:[5] I think that it is general practice to have the steel pipe clean. In our practice is it either cleaned by sand blast or

by being dipped in acid and then in alkali to remove the mill scale, and then it is dipped in a preservative cutting used in asphalt baths. Some pipes I know are dipped without being cleaned in the vats, but I think generally now they are cleaned, but there is no galvanizing placed on the lines to my knowledge. Does anybody here use galvanized pipe?

MR. RANDLETT:[4] There is one submerged pipe in Portland, 30-inch, that was galvanized and dipped.

CHAIRMAN BRUSH: [5]Do you know how it worked?

MR. RANDLETT:[4] It is still there. It was laid in 1910, and there have been no leaks.

E. A. MUNYON, (Cincinnati, Ohio): May I ask a question? I was told the other night Pittsburgh is using Dresser couplings on their water mains. If there is anyone here from Pittsburgh, will he kindly tell me if that is a fact?

CHAIRMAN BRUSH:[5] We have some Pittsburgh men here, but I do not see any of them. Is there anyone here using Dresser couplings on their mains?

JAMES E. GIBSON (Charleston, North Carolina): We are not using Dresser couplings on our mains, but I know of an instance in western Pennsylvania where the main was laid in a side hill cut and there was a slow movement of the ground, where Dresser joints were used very satisfactorily.

S. B. MORRIS:[9] There are two things I should like to mention from our own experience. One is we have used a banded cement joint on very much lighter pipe and without any difficulty. About sixteen years ago, we laid a 24-inch pipe line with only No. 10 gauge steel, and have cement banded joints on that pipe line which have not given us any trouble in the sixteen years that the line has been under operation.

I might say, in this connection, that we do not use a pure neat cement such as most of the companies or cities are using. We use

[9] Chief Engineer, Water Department, Pasadena, Calif.

two parts of cement and one of sand. We believe we get a jointing material that has a little less shrinkage and can be used slightly damper and tamps a little better than the pure neat cement.

The other matter which I would mention is that of electrolysis. In our experience, electrolysis is not at all confined to the streets upon which railroad tracks exist, and in many cases the most severe damage may be at long distances from a railroad track, largely dependent upon the nature of the railroad system, the negative return system, and the nature of the water system. The installation of occasional joints in the steel pipe lines is comparatively hazardous. I know in Los Angeles, they have had some places where the cement joints have been taken out by electrolysis where there were only a few cement joints, and a long line of continuous pipe. It is very necessary to guard against that matter. In fact, the practice of using cement joints on all cast iron pipe and then using cement joints on all the steel pipe such as Los Angeles is now doing, preserves a system which has no ability to pick up any material amount of current.

CHAIRMAN BRUSH:[5] I should like to ask you, Mr. Morris, whether in your cement joint on that thin steel line, as I understand, you used a steel ring and packed it with cement. Was that ring the same diameter throughout or was it drawn in at the ends?

MR. MORRIS:[9] It was the same diameter throughout, and of the same weight of material as the 24-inch pipe.

CHAIRMAN BRUSH: And how deep were your cement joints approximately, do you recall?

MR. MORRIS: I believe about five inches.

CHAIRMAN BRUSH: Do you find it necessary to put in any form of proving material so as to give a roughness to the inside to prevent the cement being forced out?

MR. MORRIS: It was necessary to scrape off the dip very thoroughly before the cement joint was laid. In fact, that is our practice with all bell and spigot work with cement joints. We are very careful to scrape out the dip before the joint is made. The only failures which we have had with cement joints have been places where a material amount of dip has been left in the bell and the water has forced through that dip.

WATER SUPPLY FOR AIRPORTS[1]

By S. F. Newkirk, Jr.[2]

The task of furnishing an adequate and reliable water supply for airports is one that is causing no little concern to those who are responsible for water supplies. The rapidly increasing number of airports with the presence of unusually inflammable materials, many of which have little or no water supply for fire prevention and extinguishment, has brought to the foreground in many localities the question of how these airports are to be supplied. A fire loss of $1,600,000 in fourteen fires has also called the attention of the aeronautical industry to the fact that some means of combating fires at airports must be provided.

Since time immemorial, transportation has been a vital necessity to the economic welfare of every city. Steamboats, railroads, automobiles and aircraft, all have irreplaceable rôles in our general transportation system. Obviously, aircraft offers advantages not provided by the older and slower means of transportation.

The mail and passenger planes flying between San Francisco and Chicago cover a route of 317 miles shorter than the railroad and 451 miles shorter than the transcontinental automobile highway. The air mail route cuts 301 miles from the rail distance between Los Angeles and Seattle. A plane makes the trip in 12 hours against 40 hours by rail.

The average cruising speed of an airplane is 100 miles an hour as against 45 for fast passenger trains, 30 for local passenger trains, 25 for automobiles, 22 for motor buses, 22 for fast ocean liners, and 15 for ordinary ocean liners.

Air transport, business aviation and commercial aeronautics are here to stay. The least imaginative of our citizens can see, even at this early stage in the development of aerial transportation, that soon the individual airplane will become more common than it is to-

[1] Presented before the St. Louis Convention, June 6, 1930.

[2] Superintendent and Engineer, Elizabethtown Water Company Consolidated, Elizabeth, N. J.

day and will affect the lives of thousands, if not millions, of our people, who will make personal use of the plane for everyday transportation.

The federal government is developing an extensive system of national airways which bids fair to become in time almost as comprehensive as our national highway system. Powerful revolving search light beacons, with flashing course-light projectors for indicating the direction of the airway are being installed at 10-mile intervals. At 30-mile intervals boundary-lighted intermediate landing fields are being established and equipped.

United States air transport routes now total approximately 37,000 miles, of which nearly 12,500 miles are lighted for night flying. All of these airways and navigational aids, however, would be useless if we had no airports, just as lighthouses and other aids to marine navigation would be of small value if there were no ports or harbors in which ships could anchor and find shelter.

Progressive cities are determined to have adequate airports to attract air commerce and its accompanying industries, as they recognize the fact that they must provide themselves with suitable air terminals if they are to have places in the great air transportation system that is rapidly spreading over the country. Chambers of Commerce, civic bodies, and municipal and county organizations are wide awake to the need for efficient airports, with the result that a large number are being constructed and projected. In a few years the municipality that lacks a landing field for airplanes will suffer in prosperity and esteem. In 1929, government traveling airport specialists visited 636 cities and delivered 251 addresses in municipalities interested in obtaining airports. A carefully selected chain of airports establish in or near all cities and the most important towns is essential to meet the needs for landing of the many planes now in constant use, and to care for the great increase in the near future.

The location of an airport has depended, in most instances, upon the field available and the cost involved, whereas climatic conditions, visibility, prevailing winds and general surroundings play an important part in the space required. Most airports are located a reasonable distance outside of a city on an arterial highway or main line railroad providing rapid transportation to the center of the city.

To emphasize the growth of aeronautics, it is interesting to note that 4,761 military and commercial airplanes were produced in the United States in 1928, and 6,034 in 1929, and on January 1, 1930, there were 10,596 holders of pilot licenses and 31,391 holders of

student permits. Aids to aviation in the next federal budget, beginning July 1, are $22,517,630—about one-half of the amount allotted to merchant marine. The total distance flown by all aircraft during 1928 was 65,658,936 miles.

On January 1, 1930, here were 1,603 municipal, commercial or private airports, Army and Navy stations, Department of Commerce intermediate fields and other marked auxiliary fields, an increase of 556 in two years. In addition, there are more than 4,000 fields owned by states, municipalities, corporations, clubs, commissions and individuals, on which landings may be made, but which are not permanently recorded, as they are constantly changing in character, and a permanent record would be of variable value. Also, in 1,274 cities additional airports of one grade or another are under discussion.

WATER SUPPLY FOR AIRPORTS

In the construction of an airport much time is given to the study of a proper layout, drainage, clearance, grading and surface lighting, but little or no thought is given to water supply.

The Aeronautics branch of the United States Department of Commerce, in their rating of airports when considering fire-fighting equipment; are guided in a large measure by various standards of the National Board of Fire Underwriters. The National Board has not published any standards for protection of airports, and standardization must not come too soon in a field so overwhelmingly in its ascendancy and so profoundly subject to revolutionary advancement. The National Board and the aeronautical industry have differences of opinion regarding fire protection requirements, and the National Board is now awaiting the outcome of various tests before publication of requirements.

An airport is often located at a considerable distance from a public water supply, and the cost of extending the system is prohibitive. The rapid rate at which water is required during a fire requires large mains, so that even when airports are near a public supply, they are sometimes at a remote distance from an artery.

An airport in New Jersey has had two fires with a total loss of $500,000 and, quoting from a local newspaper, "No water was available on the field and firemen were forced to lay several hundred feet of hose and draw on wells on nearby farms." The nearest fire hydrant to this field is 1.9 miles distant, and the nearest water system artery, which is a 36-inch pipe under 80 pounds pressure, is 10,000 feet dis-

tant. To supply this field satisfactorily it would be necessary to lay an 18-inch line at a cost of about $60,000, and provide an elevated tank for reliability. Under utility regulations the private water company nearest this port would need to extend their system upon receipt of a deposit of about $15,000, refundable as other consumers connected to the extension. This company would probably lay a main costing about $21,500, as they would realize that an extension meeting the requirements of the utility commission would give little fire protection, and the water company would be willing to add that much additional in order to give better service. If this latter extension were made and elevated storage of 50,000 gallons and a ground storage of 500,000 gallons were provided, there would be a sufficient supply. The owners of the airport rather than furnish this comparatively small amount, a portion or all of which might be refunded to them, have instead suffered a half-million dollar fire loss at the port.

Where the airports are so located that it is impractical to obtain a water supply from an existing system, a supply will need to be developed. This supply will usually be from wells, as it is seldom that an airport is located near a surface supply that has any appreciable dry weather yield. It will also probably be costly to provide sufficient wells and well-pumping equipment to maintain the rate necessary for fire-fighting, so storage will need be resorted to. The quantity required, which of course will vary in different ports, will probably be too great for elevated storage, so that a combination of elevated and surface storage will need to be resorted to. The surface storage supply will have to be raised to the piping system by fire pumps. In all cases where an adequate fire flow cannot be obtained from an existing system, storage, both elevated and surface, should be provided. The elevated storage should be sufficient to supply the required fire flow for about thirty minutes, and the combined elevated and surface storage should be sufficient to meet the requirements for a period of two hours.

Ground storage need not be in expensive concrete cisterns. Large wooden tanks similar to those used by the government during the war could be used. Fire pumps should be housed in a detached building of incombustible material. Electric power could usually be used for driving pumps with internal combustion engines for stand-by service. Water mains should be of cast iron and 8 inches should be the minimum size, with larger sizes determined by carrying capacity

necessary from source to point of use. Hydrants should be of sufficient size to meet the standards of the National Board of Fire Underwriters and where possible should be in a structure with hose attached. Care should be taken in selection of hydrant locations so as not to interfere with flying operations. Post indicator valves should be used as much as possible.

Effect of design of hangars

In conjunction with the study for a source of supply, it is necessary to know just how much of a supply is necessary, and, in order to estimate, it is necessary to decide what fire-fighting facilities are to be furnished. This depends upon the type of construction used for hangars and the features of heights and areas. The type of construction generally used is frame, sheet metal and masonry walls, with a wooden roof supported on steel or built-up trusses. The masonry type of construction with some variations is generally employed by the larger transport companies and many of the cities that have more recently built airports. The sheet metal hangar is extensively employed, and frame hangars are found at the old landing fields. In some cases, hangars are used for general shop and repair purposes, and, in such cases, mezzanines are frequently constructed to provide storage facilities. Frequently the hangar is constructed with leantos on two sides, housing repair shop, heating equipment, offices and rest rooms.

Heights are necessarily great, and the clearance from floor to bottom of lower chord of the roof truss is steadily increasing as the size of airplanes is increasing. The feature of height is important from the fire-protection view point, as it affects the design of sprinklers and the efficiency of hose streams. At present there are none other than single-story hangars, but the aeronautic interests state that space is at a premium and provisions should be made for two-story hangars and for basements beneath hangars. Basements are objectionable because they form pockets wherein vapors may accumulate.

The area of a hangar is necessarily important, as in structures of large area fire protection becomes a serious matter. A standard hangar area should be only moderately large and increases in dimensions beyond the standard should only be allowed where protective appliances are provided, which will, through automatic operation, extinguish many fires in their incipient stage. Of even more importance, if the fire is not extinguished, these devices, such as automatic

sprinkler systems, will cool the air down below the ignition point of the material in storage and will largely clear up the smoke, so that men can enter and extinguish the remaining fire. The areas of the older hangars are relatively small, that is, 6,000 to 8,000 square feet, but in recent years areas of 9,000 and 14,000 are common practice. The tendency at present is to considerably increase these areas.

Sprinklers under discussion

The aeronautical industry does not regard the installation of automatic sprinklers favorably, but fire prevention engineers are of the opinion that the nature of the occupancy is susceptible to protection by automatic sprinklers, and no convincing reason has been advanced as to the inability of automatic sprinklers to cope with fires in hangars. The arguments being advanced against the use of automatic sprinklers in hangars are about the same as were formerly advanced against the installation of automatic sprinklers in garages, but in fires in sprinklered garages, over a seven-year period, the sprinkler operation in 97.8 per cent of the fires was satisfactory.

Tests made at the Newark airport on a sprinkler system equipped with automatic, thermostatically-operated, quick-opening valves indicate that such equipment will successfully control airplane fires liable to occur in hangars, and such equipment, with ceiling and floor sprinklers, will probably confine a fire to one plane unless the fire starts between two or more planes at the same time, in which event it is likely that the fire would be confined to the immediately adjoining planes without involving others in the hangar, and serious damage to hangar structures is not likely to occur. This type of equipment requires a large volume of water, about 3,000 gallons a minute.

In addition to an automatic sprinkler system, inside standpipes and hose and outside hydrants should be supplied.

The total quantity of water required for most airports would be an elevated tank of about 50,000 gallons capacity and surface storage sufficient to augment the normal supply so that three 1,000-gallon fire-pumps could be adequately supplied for a period of about two hours.

The question of fire protection at an airport is a real problem and one that is not so easily solved as might be expected, but an airport is principally a public utility and is responsible for loss of damage to a plane while stored in a hangar. In many hangars signs are displayed to the effect that the owner of the hangar is not responsible for any

loss or damage to the plane. This is, of course, no protection if the owner of the plane can prove negligence on the part of the hangar management and the same rule will possibly be applied by the courts to this question that now applies to the storage of automobiles in garages.

Water is the best fire extinguishing agent for airports, and all water works officials should do everything possible to assist airports to obtain a suitable and satisfactory supply. When an extension of an existing system is unsatisfactory, then they should assist by advising on the development of a local supply.

DISCUSSION

CLARENCE GOLDSMITH:[3] Whenever a new problem arises in fire-protective engineering, its final solution necessarily is based on and dependent upon experience. Mr. Newkirk's paper on "Water Supply for Airports" is a very timely one, for, as has been brought out, the airplane industry is now firmly established and on the eve of a rapid expansion.

The first concern of those connected with the industry along the lines of fire safety was, naturally, for the plane in flight or in crashes, and early in 1925 the Equipment Section of the Material Division of the United States Army Air Corps started a research into the cause and for the prevention of such fires. Coincident with this move, the underwriting interests and the industry gave serious thought to the protection of hangars, and the automatic sprinkler interests have developed special protective features for this hazard.

For the past several years there has been a considerable diversity of opinion among the interested parties regarding the efficacy of the different types of protection. Manufacturers of automatic sprinkler equipment conducted several practical tests in Akron, Ohio, nearly a year ago. In November of last year the City of Newark, New Jersey, conducted tests in the Colonial Hangar at the Newark Metropolitan Airport. This hangar is an exposed steel-frame structure, 120 feet by 120 feet, 35 feet high, and is protected by overhead and floor type sprinklers. A number of tests were conducted and the extingushment of fire in airplane wings and large quantities of gasoline was satisfactory in all the tests. Some of these appeared to be fully as severe as would be met in actual practice. The quantities of

[3] Assistant Chief Engineer, The National Board of Fire Underwriters, Chicago, Ill.

water required to serve the equipment ranged, according to the volume of the fire, up to about 3,000 gallons a minute.

During April of this year a Fact-Finding Committee on Automatic Sprinkler Protection for Airplane Hangars, sponsored by the Aeronautics Branch of the Department of Commerce, Washington, D. C., conducted a series of tests on a frame hangar especially built for the purpose. This Committee has not as yet issued its report. The tests, however, showed that automatic sprinklers, when supplied with ample quantities of water, will hold fires of serious proportion in check and prevent the destruction of the hangar.

It cannot be expected that any type of protection can prevent the destruction of the fabric on the wings and fuselage of a plane when these have been treated with nitrocellulose "dope," for the rate of complete combustion ranges from about one minute to a little over two minutes, depending on the size of the plane. Cellulose acetate treated wings burn much slower.

Ten tests were run in Washington, D. C., and quantities of water up to 2,400 gallons a minute were discharged from the system in the several tests. Although the wings burn rapidly, the application of water by the sprinkler system prevents the spread of fire to the building, and, in most cases, to other planes, even when gasoline lines have been ruptured. The total quantity of water available to furnish satisfactory protection must be sufficient to keep the sprinkler system in operation until the fire due to burning gasoline has died out for lack of fuel. Sprinklers do not put out a gasoline fire, but confine it in a narrow radius.

If a hangar is filled with airplanes and the airplanes are so stored that the wings do not overlap, and if there are no gasoline leaks on the floor and no accumulation of gasoline on the floor, and a fire originates in one plane, it may be expected that the sprinklers will confine the fire to the particular plane where the fire originates.

At the present time, data at hand indicate that with properly engineered sprinkler systems a supply of 3,000 gallons a minute at 50 or 60 pounds, when draft is being made, should be available for the duration of a period of at least one hour. Few airports are so located that such a volume can be obtained from an existing distribution system, and, if it were available, it would be the exceptional condition where satisfactory pressure could be maintained. Therefore, the problem resolves itself into providing local storage near the hangar. The aeronautic industry is opposed to the erection of elevated tanks;

therefore, ground storage must be utilized. Owing to the transitory condition of the industry, it is doubtful if reinforced concrete underground storage reservoirs are justified, but wooden tanks for pump suction purposes, having capacities of 200,000 gallons, can be installed above ground near the hangars.

In order to furnish an immediate supply of water under pressure, one, two, or three 9,000-gallon pressure tanks should be provided, and, where 3,000 gallons of water per minute is needed, two 1,000-gallon fire pumps will be able to furnish this quantity of water under the required pressure. Where electric power is available, these pumps, naturally, will be motor-driven; otherwise, gasoline engines can be utilized to advantage. In calculating the quantity of water required, the discharge from each sprinkler head should be figured at 15 gallons a minute for 60 minutes, except where a large number of heads is involved. The total gallons under this formula may be reduced somewhat, provided ceilings are subdivided through the installation of drop curtains at least 20 inches deep on flat ceilings, which are supported on the lower chord of the trusses, and extending from the roof to the lower chord of the trusses when open, so that there will be not more than about fifty sprinklers in any one area. Sprinkler heads should be so spaced that heads serve between 60 and 64 square feet. If protection is furnished in accordance with these requirements, it will be seen that the quantity of 3,000 gallons of water a minute will only provide protection in a hangar not exceeding 12,000 square feet in area. At the present time, the tendency is to construct hangars of much greater size. The recently completed Detroit municipal hangar has a floor area of 200,000 square feet, and the hangar at the Curtis Airport at Glenview is almost as large. The providing of protection for such areas as these, in accordance with the above-mentioned standards, would be economically impossible. Nevertheless, the maximum quantity of water named, that is, 3,000 gallons a minute, can be made to furnish a very satisfactory degree of protection, providing the sprinkler system is properly engineered by utilizing open heads controlled by heat actuating devices to subdividing the area by water curtains and by protecting the sections thus subdivided by either open or closed heads, or the combination of both.

Some allowance should be made for hand hose lines so that they may be available for use by private fire brigades in order to support sprinkler system by extinguishing fire beneath the wings and in concealed spaces where water discharged from the sprinklers cannot reach.

Where hangars are located so close together that they form mutual exposures, additional quantities of water may be needed to prevent the spread of fire from hangar to hangar. However, when the enormous cost of providing additional supplies of water is taken into account it would seem more advisable to protect the exposures by suitable wired glass windows and shutters on wall openings and building parapets high enough to protect the roofs.

The large values involved in the hangars themselves and the planes which they house certainly merit careful consideration and the furnishing of an ample water supply. Fire protection required to control fires not only means the conservation of burnable values, but may also be a means of preserving the integrity of transportation schedules. Waterworks men should be consulted at the inception of any project, and they in turn should work out the ways and means of furnishing an adequate and reliable supply of water.

HERMAN ROSENTRETER:[4] The writer has read Mr. Newkirk's well written paper on "Water Supply for Airports" with great interest and can find nothing material to add to it except some statements confirming the conclusions reached as to the amount of water necessary for proper fire protection of hangars.

Newark has been building an airport at which there are at present 6 hangars. Two of these, each having 14,400 square feet of floor space, are equipped with a "Deluge" sprinkler system. Prior to the installation of this system in the "Colonial Airways" Hangar, a flood test made by the Division of Water at the request of the "Schedule Rating Bureau" showed an initial pressure of 50 pounds, with two 2¼-inch nozzles open on each of 2 hydrants, the pressure on the third hydrant dropped to 37 pounds, and the delivery of water at the two hydrants amounted to 2480 gallons per minute at 37 pounds pressure.

Later on an exhaustive fire test of the sprinkler system in the "Colonial Airways" Hangar was made. This test tended to show that the sprinkler equipment was successful in combating gasoline fires.

On April 5 a fire occurred in the same hangar which was put out by a combination of the sprinkler system and patent extinguishers.

A report on the fire is shown in the Appendix. Copies of the detailed reports on the sprinkler equipment will be mailed to those interested upon written request.

[4] Division Engineer, Division of Water, Newark, N. J.

APPENDIX

Report on Fire at Colonial Transport, Inc., S. S. Port St. Newark, N. J.

Regarding report on fire, which occurred Saturday, April, 5, 1930, at 3:30 p.m.:

In view of the fact that there have been conflicting reports regarding the extinguishing of fire in aeroplane at the above hangar, inspector again visited the property today, and reviewed with Mr. Perkins, Traffic Manager of the Company, the circumstances in order to determine, if possible, the methods used by employees to extinguish the fire and also to determine definitely the action of the Deluge Sprinkler System installed.

It appears definite that Fairchild plane was resting midway between No. 1 and No. 2 bays of the hangar, with wings folded back, while several men were working on it, when fire suddenly occurred in the left wing, due to a short circuit in wire leading to the landing light. Within the next two or three minutes, the following occurred.

While one employee manually tripped the Deluge valve controlling sprinklers in bay No. 2, wetting down the plane, as well as the workmen, it being noted that sprinklers in Bay No. 1 functioned automatically a few seconds later, other workmen seized one quart Pyrene and two and one half gallon Phomene hand extinguishers to combat the fire. There were no floor sprinklers in the section where the plane was stored. Comment was made by employees to the effect that extinguishing agent in these hand extinguishers while, no doubt retarded the fire, were of insufficient force, and apparently flowed off of the wing, preventing their having full effect. Meanwhile another employee backed a tractor, which was also stored in the hangar, up to the still burning plane, with which it was removed from the hangar, and a forty gallon portable Phomene extinguisher was immediately discharged on the remaining fire and thereby extinguished. Employees observed that it seemed to be the force or pressure from this forty gallon extinguisher as much as the Phomene which finally extinguished the remaining fire.

From the foregoing, it will be noted that it was the combination of both sprinklers and chemical extinguishers which were ultimately responsible for successful extinguishment of the fire. Four one quart Pyrene, four two and one-half gallon Phomene and one forty gallon portable Phomene chemical extinguishers were discharged. Without the initial benefit from the action of the sprinklers, perhaps the extinguishers alone would not have been sufficient. Mr. Perkins stated that, while the extinguishers and sprinklers were holding the fire to some extent, it is doubtful in his mind as to whether they would have completely controlled the blaze. However, the deduction is that for best protection all types of extinguishing agents are necessary and desirable.

H. E. Ledward
Inspector

April 23, 1930.

DISASTER PREPAREDNESS PLANS FOR WATER WORKS[1]

By Geo. W. Pracy[2]

While the subject as assigned was of a broader scope and some may treat it in their discussions, I have, partly through misunderstanding, but for the most part deliberately, confined it to the location, design and construction of waterworks structures as they may be affected by earthquakes. Living in an earthquake zone and having had the dubious pleasure of being in the middle of the San Francisco shake of April 18, 1906, besides being a close and interested onlooker of the Santa Barbara shock of June 29, 1925, I feel that the experience gained by the water works operators in these parts through those occurrences may be of some interest to the men who may have similar conditions to meet.

Before talking of the remedy let us first look at that with which we have to contend. An earthquake, as you all know, is caused by the sudden movement of a portion of the earth's crust, which produces a shaking or trembling of the ground. It is the result of a shearing or slipping of one portion of the earth along another portion. The line along which this shearing or slipping takes place is known as the fault line. In the San Francisco earthquake this line was plainly marked for a distance of 200 miles with displacements as great as 16 feet. The intensity of earthquakes is measured by their physical effects, various scales being used, most commonly being formulated into ten divisions on what is known as the Rossi-Forel scale. Earthquakes in division 1 are those "recorded by a single seismograph or seismographs of the same model but not by several seismographs of different kinds; the shock felt by an experienced observer," while those in division 10 are "Shocks of great intensity; great disaster; buildings ruined; disturbance of the strata; fissures in the ground; rockfalls from mountains." An earthquake must be in the upper three of four divisions of the scale before it is severe enough to do any

[1] Presented before the St. Louis Convention, June 4, 1930.

[2] Superintendent, City Distribution Division, Water Department, San Francisco, Calif.

damage to a waterworks structure that is at all well built. Building structures are more susceptible to damage. Fortunately these severe shocks do not come often.

EARTHQUAKE DAMAGES TO WATER WORKS

The damage done by an earthquake may be due to any one or any combination of three causes, the intensity of the shock, the solidity of the ground and the design and construction of the structures. Professor Charles Derleth, Jr. in The California Earthquake of 1906 says:

"The intensity of the shock, however, is observed to have varied greatly, and well built structures, which rested on hard and rocky surfaces were relatively little damaged. Rocks and the structures resting upon them were shaken by an elastic vibration without differential movement, and whenever the construction was intelligent and honest it withstood the shock. There are many examples of buildings of such behavior on rocky summits in San Francisco. Comparatively little destruction was meted out in cities like Santa Cruz, San Rafael and Berkeley, which rest on rocky foundations, or other sound coherent materials.

"Within the belt of great destruction are found many localities or spots where considerable differential surface movements occurred through at considerable distances to either the east or the west side of the rift. Examination shows such localities to be overlaid with loose incoherent material. In one place we find a loose river deposit, in another a marsh and in a third an artificial fill."

The damage due to the movement of the earth at the fault line is best illustrated by the destruction of the Pilarcitos pipe line, a 30-inch wrought iron riveted pipe laid, for 6 miles, almost exactly along the line of earth movement. Speaking of this line Professor Derleth says:

"Nineteen ruptures were observed by me from a point near the northern end of Lake San Andres to Frawley gulch, a distance of about 3 miles. All ruptures occurred at transverse riveted joints. There were some places where the pipe collapsed; in one instance, for a length of about 50 feet. There were no doubt many more ruptures in this length, but they had not been uncovered. At tensile breaks the pipe was pulled apart by amounts varying from almost nothing to as much as 5 or 6 feet. At compensating places the pipe was telescoped by similar amounts. At Frawley gulch the conduit crossed a timber trestle, heavily built, about 100 feet in length and some 25 feet in maximum height. Some of the timbers of this trestle were partly decayed, but the structure certainly was not weak. This trestle was about one-quarter mile to the east of the fault line. Nevertheless, the shock was so severe that it entirely demolished the trestle and pipe which it carried."

The fault line ran through the east abutment, perhaps touching the eastern edge of the San Andres dam. The fault also passes through the old Upper Crystal dam. Evidence of the roadway fences showed that this dam must have been sheared 5 or 6 feet. At both dams the brick tunnels sheared, the displacement being from 6 to 8 feet. Both dams were earth dams with clay cores, San Andres being 95 feet and Upper Crystal Springs 85 feet high. Neither dam was at all damaged. At Santa Barbara the Sheffield dam slid out and was entirely destroyed. Mr. V. E. Trace, in a paper read before the California section and published in the April, 1926, issue of the JOURNAL, says:

"The dam forming the Sheffield reservoir was a puddled earth fill, maximum height 25 feet and 800 feet long, without a drainage system. The face of the fill was puddled with black adobe, 4 feet at the bottom and 2 feet at the top and 9 feet in depth below the bottom of the reservoir, a concrete cut off wall one foot thick and 5 feet in depth, placed in front of the adobe, the concrete lining extended therefrom covering the face of the dam.

"Upon examination of the old structure there was left after the major portion went out, we found that the adobe facing and cut-off wall was perfect, no water having percolated through the adobe, but the hydrostatic pressure in the reservoir caused the water to percolate underneath the cut-off wall and adobe fill and saturate the bottom of the main structure.

"When the heavy shock took place, the dam opened near the south end and about 500 feet in the center slid out on a hinged form."

The stability of the San Andres and Upper Crystal Spring dam and the explanation of the failure of the Sheffield dam leads to the conclusion that a properly designed and constructed earth dam is safe even under very severe earthquake shocks. In the San Francisco earthquake there was no damage done to any distributing reservoir except to crack the western wall of the Lake Honda reservoir. This was an old reservoir built in a natural hollow with a bank 100 feet high on the western side. Mr. Schussler says:

"All the three large pumping plants in San Francisco were not injured by the earthquake, as well as the ones at Millbrae and Crystal Springs. At Belmont Pumping station the only slight damage done was the breaking of a flange on a steam valve on one of the five pumps. These pumping stations are all built on solid ground."

A study of the damage done to the pipe lines is interesting. Three large pipes, a 44- and two 30-inch riveted wrought iron lines brought the water from the lakes to the City. The westerly line, a 30-inch,

lay nearest to and for 6 miles directly on the fault line. This line was demolished for these 6 miles, but not injured for the rest of the distance, it being in solid ground. The next line lay about two miles east of the fault line, parallel to it and in solid ground except for a few hundred feet where it crossed a marsh. It was broken where it crossed the marsh, but in no other place. It was repaired and was again supplying water to the City sixty-two hours after the earthquake, in spite of the general demoralized condition of the City. The third line, the 44-inch, was laid for quite a distance on trestle across the marshy land along the bayshore. This line was destroyed for a length of 2850 feet, and also was broken in seven places between the Crystal Springs dam and the Millbrae Pumping Station, a distance of eight miles. The 30-inch Alameda line, 20 miles long and running from Niles to Belmont was not damaged in any way, although it rests for 3½ miles on trestles across marshland and for several miles more in ground that is none too solid. This line also includes four submarine pipes, two 16- and two 22-inch ball and socket joint pipe 6400 feet long under San Francisco bay and four shorter submarine lines about 500 feet long under a slough. Mr. Schussler's story regarding this pipe line and the earthquake shock is as follows:

"At the time when we built the first submarine lines and the 36-inch pipe, during 1887 and 1888, fearing that the watchman might shut the submarine gates down too suddenly, with a strong current of water flowing from Niles tank towards the submarine pipes, I put on an automatic safety valve at the east side of the slough and the bay, in order to lessen or avoid all shock danger to the eight or nine miles of 36-inch pipe that might be caused by the sudden shutting off of the submarine pipe gates. These automatic safety valves had a number of large rubber disks, which were regulated carefully to open automatically at the slightest shocks above the normal pressure. East of this shock valve I had a tall air chamber, where any air in the 36-inch pipe would collect and could be let out. I knew that the bottom of the bay and the bottom of the slough were not perfectly level, and that there might be high places in the pipe where any air getting into the same might accumulate. I, therefore, put up these air chambers to prevent any air from entering the submarine pipes. Eastwardly from the air chamber and close to the same was placed a vacuum valve, on top of the 36-inch pipe, which valve would open instantly and automatically, the moment the pressure was taken off the pipe by a break, or whenever it was emptied, for repair purposes, by opening a blow-off gate.

"At the time of the earthquake, on the morning of April 18, the water was coming westwardly, at the rate of fully 16 million gallons daily, through the 36-inch pipe, having a mean velocity of fully 3½ feet per second. The water was flowing towards the bay with that velocity, going through the submarine pipe and towards and to the reservoir at Belmont. When the shock came

the vacuum valve instantly dropped and let air into the pipe, showing that at that point east of San Francisco Bay the first shock observed came in a southwestwardly direction. It further showed that this shock was much more rapid than the velocity with which the water flowed in the same direction. The vacuum valve fell down, and when the reaction shock came, from southwest to northeast, the valve closed suddenly, throwing up a stream of water into the air while closing. At the same instant the safety valve nearby opened automatically, closing when the shock was passed, and thus by discharging quite a quantity of water relieved the long 36-inch pipe to the east from the effect of the shock, which might have been disastrous."

In San Francisco there were just three hundred breaks in the pipe system of 442 miles of pipe. These breaks occurred almost entirely in areas where the ground had been filled, the greater part of the water front land being formerly marsh or low tidelands that had been filled. Mr. Schussler attributes the breaks in solid ground to the use of dynamite as a means of preventing the spread of the fire.

Again quoting Professor Derleth:

"In Santa Rosa no breaks occurred in the water works system, its artesian sources of supply, or its pumps. A few house service pipes broke at the house lines.

"San Jose's water works, like that of Santa Rosa, was not injured; its sewers were also left intact, showing that there was no unequal displacement of the ground."

Of the Santa Barbara earthquake, V. E. Trace, Superintendent of the Water Works, writes:

"The first break in the system noticed was the 12-inch class "B" cast iron main on State street, and was caused by the falling of a top wall from a three story building landing directly over, and driving the pavement three and one-half feet into the ground. The 8-inch cast iron main on Mason street was severely shaken causing several leaks in lead joints, also fracturing two cement joints and shearing off several services at the corporation cock. . . . . The 8-inch cast iron main that crosses the bridge on Haley street broke within six inches of the concrete wall. . . . . On Chapala street one cement joint was fractured and one service was sheared off. . . . . A section of the de Lavaud cast iron pipe in Cliff Drive moved ahead 2½ inches and was replaced with a longer section. . . . . In various sections of the City where 2-inch standard pipe was installed the joints were buckled. . . . . At the pumping station, the 10-inch standard screwed discharge main from the pumps connecting with the distributing system, separated at the joints. In Montecite street a lead joint was leaking and the expansion joint in the pavement raised. In Bath street one lead joint was leaking. The concrete pipe, being a short section of about 50 feet, was cracked in three places; two were vertical and one horizontal in the elbow underneath the surge chamber."

At Santa Barbara the Mission tunnel, 19,560 feet long, running through the range just east of the City was uninjured.

PRECAUTIONS IN DESIGN AND CONSTRUCTION

With the foregoing in our minds we can now turn to the precautions to be taken when designing and constructing a water works in places subject to earthquakes. These precautions are concurred in by all who have had experience along these lines, the question of the extent of these precautions having to be decided in each case.

The first and most important is the making of a complete survey of the country to determine the extent, location and degree of activity of all earthquake faults. The necessary judgment must then be used to determine the degree to which the structures may be built over or adjacent to the faults. If it is necessary to build on or near the known fault lines the additional factor of safety and other precautions to be taken must be decided. The mere fact that a fault line passes through the dam site is not sufficient reason for its condemnation as is evidenced by the location of the Owyhee, Stony Brook and Roderiquiz dams.

Mr. S. B. Morris, a member of this Association, and C. E. Pearce have written an interesting article on the design of a non-overflow concrete gravity dam to resist earthquake.

Care should be taken to keep long supply lines on solid ground and away from fault lines.

The new 54-inch pipe laid from Lake San Andres to San Francisco was necessarily laid close to the San Andres fault line. To determine its exact location a study was made of the zones of varying intensity of the 1906 shock. Due to the character of the ground this intensity diminished for a certain distance from the fault line and then again increased. The line was laid in the zone of least disturbance. The outlet structure for this pipe consisted of a tunnel through the hill with a shaft, with the control gates, located near the lake. The short piece of tunnel from the shaft to the lake would, if carried through, as in normal construction, cross the fault line. To avoid this the tunnel was run to a point east of the fault and a large open cut made to bring the water across the fault to the tunnel. The slopes of this cut were made 5 to 1 to insure stability. In addition slots were left in the lake end of the tunnel structure so that a bulkhead could be placed and the tunnel unwatered. A heavy iron door, bolted on to form a water tight joint, gives entrance to the tunnel from the shaft.

At San Francisco it was found that some lines rigidly fastened to the pile structure were more badly damaged than other lines that were so constructed that the pipe could move from side to side independent of the motion of the trestle. In any city distributing system the main pipe lines should be on solid ground, the pipes in the filled portion of the city being so arranged that they can be easily shut off in case they are ruptured.

It has been suggested, but never put into effect, that the pipe systems in the filled ground be built as independent distributing units, being fed through two gates of proper size. This would enable these portions of the city system to be shut off very rapidly, preventing the draining of the reservoirs and leaving the undamaged portion in operation.

In the construction of the high pressure auxiliary water supply system built in San Francisco after the earthquake of 1906 a double spigot pipe, cast iron, with a sleeve joint was used in the filled ground on the assumption that the double lead joint would allow more freedom of motion without damage than would be possible with the regular bell and spigot joint. In the report recommending the construction of this system it was planned to so lay the mains that in the high building district the top of the mains would be not less than five feet deep and in the outlying sections three and a half feet deep. We have before noted that in Santa Barbara the top wall of a three story building fell and drove the pavement 3½ feet into the ground. Mr. L. B. Cheminant (High Pressure Fire Protection in San Francisco, Bulletin of the Seismological Society of America) says that:

"All pipes were laid at a depth of at least five feet to minimize danger of breaking by falling buildings."

Mr. Carl Wyant, Resident Engineer of the Montecite County Water District, which district is just adjacent to Santa Barbara has summed up his opinion as follows:

"Our distributing system consists of de Lavaud centrifugal cast iron pipe made with cement joints. After the Santa Barbara earthquake an inspection showed that our lines went through the shock without a leaky joint. The only trouble was in one place where a 12-inch pipe was broken due to a crack in the ground about 6 inches wide. Therefore, I think that cement joints are entirely satisfactory for earthquake conditions.

"I feel that wherever practical duplicate mains should be laid from the source of supply to the distribution system, and where this is not possible sufficient storage near at hand should be provided, to enable any possible repairs to be made. We have duplicate lines from our tunnel to the distributing system and have provided a line to make interchange with Santa Barbara possible. As you probably know our source of supply is partially from seepage water in a two mile tunnel and partially from a reservoir on the Santa Ynez River which is conducted through the tunnel to the coast side of the mountains. Santa Barbara has a similar situation. We feel that by tying the two systems together the danger from collapse of our tunnels is greatly reduced as they are about eight miles apart and pierce different formations.

"Together with Mr. Trace, I inspected the Santa Barbara tunnel after the earthquake and found that no damage had resulted. Our tunnel was under construction at the time, but our men happened to be at breakfast at the time of the first big shake, but they went right back in the tunnel and although we had shakes all that day they did not notice them at all. I am, therefore, of the opinion that unless a movement occurs on a fault which crosses a tunnel, that in solid rock the movement is reduced to a very rapid vibration and small throw and will cause no trouble.

"I feel that reservoirs should be placed on rock foundations wherever possible. Our small reservoirs were so situated and the shake had no apparent effect on them. In reinforced rectangular reservoirs I think it is well to tie the sides together in the center with a low reinforced wall. This also allows the reservoirs to remain in service while being cleaned out.

"My opinion is that on rock foundation a thin arched dam is very satisfactory in earthquake regions. This is based largely on the fine manner in which Gibralter Dam withstood the shake.

"On less solid foundations I believe that hydraulic fill dam will be most satisfactory. We have built one about 100 feet high in this manner. In addition to the puddle core in the center we put a concrete cutoff wall at the upstream toe and lined the upstream face with 2-inch of reinforced gunite divided into 24 feet squares with copper expansion joints. I feel that this type of structure is much more flexible and consequently more earthquake proof than a rolled fill.

"I feel that no dam should be constructed without the services of a competent geologist, and of course since the new law the State Engineers Office will see that this is done.

"In places where pipe lines cross an active fault, I think it would be well to provide expansion joints on either side, and in remote locations, an extra length of pipe left for emergencies."

The San Jose Water Works, which supplies that city with water, largely pumped from wells by motor driven units, has constructed an emergency plant containing two 300 horse power gasoline engines direct connected to generators, the units being housed in a building which has been made as earthquake proof as possible. These units are of sufficient size to operate the main pumping station which is located alongside of the generating plant.

The personnel of a public utility should be so trained as to be able to act promptly and effectively in case of an accident. Fortunately, these emergencies usually affect only a portion of the system. A greater catastrophe would merely involve more stations and more men.

Both private and public telephone lines connect the main offices, the necessary men are on duty at all times, and automobiles are always available. Any changes from the normal operating condition should be immediately relayed to the nearest man in charge of the system. Only men possessing the necessary judgment should be placed in jobs requiring quick and independent action. These men should be encouraged to do their own thinking. Detailed action must depend upon the conditions met.

DISCUSSION

E. L. Filby[3]: Every state with the exception of Delaware has had disasters of great enough magnitude to warrant relief work by the American Red Cross. In 154 cases in 39 states, floods have been the cause, in 227 cases in 34 states, hurricanes, tornadoes or cyclones occurred, while fires called for relief in 114 cases in 38 states. It is not known just how many of these disasters involved water works, but we can easily picture the water works in disasters such as:

1. Floods, overflows, tidal waves
2. Wind, tornado, cyclone, hurricane, coastal gales
3. Drought or supply failures
4. Disease outbreaks
5. Earthquakes

Each have separate and distinct problems calling for all the ingenuity and ability of the designer and the superintendent.

All disasters have one common base, namely; it is of paramount importance that the water supply of a community be restored to service as quickly as possible supplying a safe water and a supply ample in quantity for normal use.

To bring order out of chaos and to hasten the return to normal conditions the superintendent should prepare now for the disaster that may strike, for a normal functioning public water supply is perhaps the greatest factor in the restoration of public morale. Types of disaster common to each state are known to all, for as we have hurricanes in Florida, floods in Arkansas and Louisiana, so in

[3] Chief Engineer, State Board of Health, Jacksonville, Fla.

recent years we have had tornadoes in Texas and Oklahoma and disease in New York.

Consider your plant, is it so located as to be protected against abnormal conditions? If it is on a stream, will a big rise drown out purification units, overflow the clear well storage or wash out your intake? Suppose friend river migrates to a new channel and leaves the intake high and dry or perhaps the wind blows the water out of one end of the lake and piles it up at the other end, 8 feet higher than normal, how long can you operate? Is the long line from your intake to plant protected by being in duplicate and adequately valved? Have you recently checked it for corrosion? Are you prepared to modify your treatment in event of a sudden change in the characteristics of your raw water supply? What would you do if a phenol spill occurred on your water shed? Are you and the weather man good friends—so that he will ring you up and tell you of the heavy precipitation or thaw on the headwaters of your water shed, or to get ready for a hurricane, or the approach of a blow? Are you in friendly relationship with your railroad officials so that if you need supplies or materials in a pinch they will rush shipments through to you? Can you call up any superintendent nearby and ask him for a fitting to put a blown 16-inch main back into service and count on him to have it enroute to you in a truck in half an hour? Do you carry reserve parts of chlorinators or better still have you a duplicate unit? Are you using Chlorine Institute valves on your chlorine cylinders so that, if your neighbor runs out by accident or otherwise you can loan him a cylinder that can be used? Are you prepared to carry orthotolidine control so that you will not make the serious mistake of overdosing with the creation of tastes?

And droughts—every water works man fears a drought—are you prepared? If three wells will run the town nicely with a reserve have you two more for that drought, and should a well begin to get salty, under heavy pumping, can you rest it up by using a spare unit? Is your water bearing stratum protected against saline or mine waste polluted water? Have you an emergency supply that you can throw into service after taking all precautions to render it safe for human consumption?

And disease—can you stand in court and say I have taken every reasonable precaution to deliver safe water at all times—and still further have you the records of bacterial findings, excess chlorine determinations, and the like to substantiate your statements? I

know of one water plant that for lack of records of excess chlorine determinations was for a time saddled with the odiom of having been the transmitter of typhoid fever. Have you checked the cross connections to your supply? Courts have held the water utility responsible in case after case—a slip up on your part may be a financial disaster to your city—for damages can be collected for diseases transmitted by water.

Can you barricade your doors with sand bags to keep out driving rains or waves. Is your switch room and electrical equipment so protected and housed that you can keep water out? Are your sump pumps electrically driven, which means, if the power lines fail, your sump may fill up? Have you a gasoline driven diaphragm pump handy? Have you ample tarpaulins, lanterns, ropes, wire, bracing, buckets, tools, etc., for use inside your pump house?

Have you comprehensive maps of the distribution system and a fairly complete valve record so that certain sections can be quickly cut out to conserve water while leaks are located? Can you cut your elevated storage off the lines to conserve it? Are your men trained in quick action? If power transmission lines are down, can you get water to the local steam plant for their boilers, or have you a steam standby plant that you can get started, or better still a gas oil engine standby? Have you an agreement with the power interests to re-establish service to your plant at the exclusion of all other service? Will the local fire and police departments coöperate to the fullest? Have you ever thought of using fire engines as pumping units. They can be used if proper couplings are available. If your chemist or bacteriologist, filter operator or plant superintendent meets with an auto accident some day and must be replaced do you know of someone you can get quickly?

Many hundred questions can be asked, but the secret of success in that paramount issue, that of restoring water service to normal at the earliest possible moment, is preparation in advance of disaster.

There is one organization you can depend upon for assistance and I hope every water superintendent fully realizes this and uses that service to the fullest extent, that is, the service of your State Health Department.

In conclusion, water works men should be continually selling their plant to the public, beautifying it to attract attention, keeping ahead of demands, establishing an unblemished reputation for continuous satisfactory service. Then the public can be depended upon to respond

to your call for need. And so, look ahead, be prepared, and when disaster strikes, stop, keep your head, think it over and then get busy.

J. H. O'NEILL:[4] I have listened with much interest to Mr. Pracy's concise, yet thorough, discussion of disaster preparedness plans for water works in areas liable to earthquakes. Not knowing anything about earthquakes I am not going to attempt to enlarge on Mr. Pracy's presentation, but, with your permission, will discuss another phase of the subject, namely, preparedness against floods.

One very important difference between earthquakes and floods, as we know them in the Mississippi Valley at least, is that we usually have warning of flood levels some time in advance and thus have time to prepare for the emergency. There are, of course, places where dangerous floods have occurred with as little warning as in the case of earthquakes. However, much of this discussion is applicable to plants wherever they may be located.

The problem may be considered from three viewpoints: location of plant, construction, and maintenance under disaster conditions. The line between these, of course, may not always be sharply drawn.

Even in the low areas subject to floods in the valley, there is sometimes a choice as to plant location. If possible, the plant should be located above the elevation of maximum flood level. In 1927, a certain motor driven power and pumping plant built to replace an old steam plant, and at a lower elevation, was flooded, while the reservoir, treatment plant and abandoned steam plant were unaffected. It would have been possible at a slight additional cost to build the new plant at the higher elevation.

If at an elevation subject to flood the plant may be protected by levees or in some places by closing door and window openings to the required height by brick or concrete walls. One important detail is to see that exhaust pits, or mufflers, for internal combustion engines are protected against flooding either by levee, wall or by elevation. The plant above referred to operated for some time with three feet of water against the walls of the building, but failed when water entered the exhaust muffler pits.

Even with plants which do not normally use chlorine, provision should be made in advance so that chlorinating equipment may be installed quickly, and chlorine applied at one or more points in an emergency. State Boards of Health usually have portable

[4] Chief Engineer, State Board of Health, New Orleans, La.

chlorinators available. Manufacturers of such equipment are generous in furnishing equipment and personnel in disasters. Care should be taken to avoid overdosing with chlorine, since objectionable tastes and odors due to overdosing may lead people to use water from other sources which may be unsafe. Control of chlorine dosage by the orthotolidin test is simple and of great value. Material for this test can usually be obtained from the State Board of Health. Chloride of lime or hypochlorite solutions are usually obtainable from drug stores or laundries and may be used pending delivery of chlorine and chlorinating equipment. Plants using lime for softening can sterilize the water by overdosing to a caustic alkalinity.

Auxiliary sources of power should be provided, either by gasoline engines or supplementary power lines from other plants. The rapid development of "high lines" tying together power plants scattered over a wide area is helpful in this respect. Emergency equipment should include provision for removing seepage, waste waters, and wash water from filters. Motor driven fire engine equipment may be useful in an emergency and any necessary couplings for such use should be obtained and held as a part of reserve equipment.

Fire hydrants should be marked by flags to make them easy to find and to minimize possible breakage by boats. Red lanterns may be used at night if boat traffic in flooded streets is heavy.

Generous use of valves in a distribution system, so that sections with breaks may be isolated, is worth while in any system, but is particularly important in systems in areas likely to be affected by disasters.

SAMUEL B. MORRIS:[5] Mr. Pracy has made a very substantial contribution to this meeting by calling to the attention of the water works engineer and operator, the importance of adequate design of water works structures to withstand one of the forces commonly overlooked—that of earthquake shock. While undoubtedly we of the Pacific Coast have greater contact with such phenomena than you of the middle west and the Atlantic Coast, on account of greater frequency of occurrence, yet it is well to point out that there were the great Mississippi Valley quakes of 1812 and of Charleston in 1886, and the recent quakes off the Newfoundland Coast, each one of which was of far greater energy than that of April 18, 1906, which caused the devastation of San Francisco by fire. This latter disaster

[5] Chief Engineer, Water Department, Pasadena, Calif.

was the result of the failure of the water supply on account of earthquake, thus making it impossible to put out the many fires instantaneously started by falling buildings.

In California a very intensive research is being conducted by Carnegie Institution with principal seismological laboratories in Pasadena. A large number of seismographs have been located throughout the State, but principally in the densely populated areas of Southern California and around San Francisco Bay. The Seismological Society of America, of which I am a member, has published a map showing the principal faults and known active faults within the state. There are, therefore, much data to guide the engineer in the design of safe structures to resist earthquake shocks in California. Provision for earthquake shock is now considered best standard practice in California. In the design of a 295 foot gravity masonry dam for Pasadena, we have included provision for stresses due to an earthquake shock of acceleration of one tenth gravity or 3.22 feet per second per second.

It is not always possible to design conduit lines and distributing mains so that damage will not occur. The best that can be done is to minimize the damage which may occur from such failures and to localize its influences as much as possible.

This paper points out the added hazards to structures built on filled ground. Water mains in city streets may be broken by falling walls or cornices, even at depths of three or four feet or more. The San Francisco high pressures system is laid at depths of five feet or more to minimize this hazard of falling walls or cornices.

Mr. Pracy states the most important element in supervision of the water works system at time of disaster, is the previous employment of men having necessary judgment to take quick and independent action at time of disaster. This is of course a prime consideration. However, much may be done in training men to take such action if careful thought and study has been applied to conditions which are likely to occur through various types of disaster affecting the water works plant in every conceivable manner. In case of severe disaster by earthquake, fire, hurricane or flood, there is frequently a complete failure of all of the ordinary means of communication. This emphasizes the necessity of having trained men capable of meeting such emergencies.

There are several municipalities on the Pacific Coast that have by ordinance adopted disaster preparedness plans in coöperation with

the American Red Cross. The cities of Berkeley and Pasadena are two that have taken such action. These plans attempt to set up a complete organization chart with definite assignment of personnel to head the various subdivisions of such organization. These organization charts attempt to make use of the man power and facilities offered by the American Red Cross, the various departments of city government and all of the utilities including transportation, telephone, telegraph, water, gas, light and power, etc.

There is insufficient time allotted in this discussion to present in detail the manner of organization provided for in these disaster preparedness plans. These plans attempt not only to set out the organization chart and assignment of personnel, but also outline in brief detail, the duties assigned to each position and the manner of carrying out orde rs and meeting financial necessities.

The greatest difficulty is to keep such plans up to date with disasters occurring with such extreme infrequency. The plan, if not kept up to date, is apt to be worse than no plan at all.

The subject of disaster preparedness plans as outlined by Mr. Pracy, particularly governing that of provision against earthquake, is of decided value in showing the necessity for consideration of those matters which do not occur from day to day and yet which come unheralded upon widely scattered cities throughout the United States as earthquake, hurricane, fire, flood or other visitations of the forces of nature and with the likelihood of epidemics of disease to follow.

WATER TREATMENT FOR RAW WATER ICE MAKING[1]

By L. M. Culter[2]

After listening to a discussion of the chemistry involved in the treatment of water for municipal supplies, any description of the methods employed for raw water ice making will seem elementary. While we have made some advance from the old rule-of-thumb of "liming the water according to the ice," appearance is, after all, the final check on the most involved chemical reactions.

Since the operating engineer, in addition to his major duties, acts as "control chemist" in handling the water treating equipment of an ice plant, it is essential that the process be simplified to the extreme and be explained in the every day language that he understands. We operating engineers are inclined to consider that, if an explanation cannot be boiled down into simple language, stripped of all mystery and involved calculations, the theory is not sound. Since we have learned that the solutions of our most baffling problems lie in the simple rather than the complex, we hesitate to accept the "fifth harmonic" as a satisfactory explanation of the "ball of cotton" in the ice.

To understand the requirements of water quality for our purpose we should briefly run over the practical physics of freezing. Water in freezing tends to purify itself by expelling the dissolved solids. A possible explanation is the gradual contraction of water with lower temperature down to 39°F., followed by a rapid expansion down to 32°. Whether on account of the increased density or the subsequent rapid expansion, the tendency is for the solids to be expelled. The action is the reverse of a distillation process, although the results are equally efficient. Instead of the pure water leaving the solids in the form of steam, the solids are expelled from the pure water and mix with that remaining unfrozen.

In the case of natural ice gravity acts to carry away the discarded solids from the freezing surface. In this connection we note that the

[1] Presented before the Florida Section meeting, April 11, 1930.

[2] Florida Power and Light Company, Miami, Florida.

ice formed in the middle of the stream is clearer than that along the shore. Obviously, the current of the stream washes away the solids and entrained air as discarded from the freezing surface and prevents their being frozen in.

In the case of artificial ice, frozen in cans, gravity plays no part since the discarding forces act horizontally. The washing effect of the current of the stream is replaced by air agitation. These discarded solids gradually accumulate in the core, thus raising the concentration and increasing the difficulties of keeping the surface clean. It will be seen that it is of prime importance to reduce the quantity of the dissolved solids in the raw water to a minimum if a higher later concentration is to be avoided.

In a practical way we divide the characteristic defects in ice into two general classes. Deposits and discolorations appearing in the *core only* can be removed by treatment. Those appearing in the body of the block, as distributed crystals, white shell or, in minor form, a veil, generally termed "white butts," cannot be materially improved by treatment. The reasoning back of these deductions seems well founded.

Considering the different solids, those least soluble are most readily repelled from the freezing surface and hence gradually accumulate in the core. Outstanding examples of these are the carbonates of calcium and magnesium, iron and aluminum oxide, silica and suspended matter, all of which readily respond to treatment. The more highly soluble salts offer resistance to separation from the freezing water. If present in large quantities, they become entrapped early in the process and appear in the body of the block. Examples of these are the sulphates, chlorides and sodium carbonate. These are non-removable.

The ice maker is not interested in what can be removed from the water, but what must be retained. He requires a final water carrying the least amount of total dissolved solids, and if the character of the raw water is such that treatment cannot strip the solids down to his requirements, he must locate a more suitable water. The difference in the solubility of the non-removable salts has little practical effect on their tendency to freeze in. He is, therefore, not interested in any change in form so long as they must be retained. For this reason, zeolite and soda ash so useful in producing soft water is of no help to the ice maker. He pictures his perfectly good, removable calcium and magnesium salts changed to sodium and *retained*.

It will be seen that a treatment employing aluminum sulphate exclusively for clarification is not ideal for ice making. Here again the removable carbonates are changed to sulphates and retained. Even with highly colored waters, a lime softening treatment will remove the bulk of the color and still leave sufficient carbonate "food" to permit a complete clarification with aluminum sulphate.

Color removal is of prime importance and can be economically carried to limits that would seem extreme to the average water works superintendent. Where a municipal supply may be good with a color of 15 p.p.m., we aim at 5 p.p.m. Our practical test is to read newsprint through a 50 cc. short APHA color tube.

Color clarification is so intimately associated with the removal of bacteria that it would seem almost like cause and effect. I do not know whether Mr. Filby will subscribe to this theory, but we hold that the bacteria in water are riding on something, probably the organic color. By removing the vehicle on which they are riding, you remove the bacteria. There is left, of course, even after the most thorough clarification, the colloidal color that also carries its minute load of passengers. Lime, in addition to its efficacy as a softener and preliminary clarifier, also proves to be a mild but efficient sterilizer. Therefore, after lime softening, followed by thorough clarification and, finally, the purification by freezing, further sterilization with chlorine becomes merely precautionary.

With waters of low alkalinity carrying color and a free CO_2 content, we use a treatment of sodium aluminate and aluminum sulphate balanced to bring the final alkalinity to 10 p.p.m. For these two coagulants the optimum band is broad permitting a considerable variation in the alkalinity.

Iron, while not troublesome of itself, causes objectionable discoloration of the other core deposits when present in quantities exceeding even 0.2 p.p.m. In this connection efforts have been made to produce show-case specimens of colored ice for special occasions as, for example, green ice for St. Patrick's Day. Vegetable color added to this normal water stripped of all possible dissolved solids, concentrated in the core, leaving the body of the block as clear as that made with uncolored water. We note three points that have been mentioned above. First, there were no sulphate and chloride defects in the body of the block to be stained. Second, the color was, relatively, only slightly soluble and hence, discarded to the core. Third, the freezing process was so efficiently purifying that it stripped the dissolved color from the water.

We can employ, of course, only the simplest of chemical control tests. We concentrate our attention on the reduction of the methyl orange alkalinity, since that is the measure of the carbonates of calcium and magnesium which appear as deposits in the core. In balancing out the phenolphthalein and methyl orange reading, the lime charge is gradually built up until samples taken from the downtake after lime treatment show the "P" reading slightly less than half of the "M" at which point the latter is at its minimum point. We, of course, recognize that any further increase in the lime will raise both readings.

Following out his practical method of handling chemical problems, the ice maker distinguishes "sand" in his ice not by the reaction of acid upon the dried deposit, but by its location in the block. Real sand, he knows, settles out in the bottom along with the heavy rust particles. So called "sand" in the core, he recognizes as removable carbonates and finds the cause in an abnormal "M" alkalinity.

Small amounts of sodium aluminate are mixed with the lime in the chemical mixer to speed up the action of the lime and to coagulate the resulting sludge. Its proportion to the lime depends upon the strength of the lime charge and the amount of free CO_2 present on which the aluminate reacts.

Our softeners provide for a retention period of 15 minutes in the downtake for the lime reaction. With most waters this period is ample. We note with some the lime reaction is retarded; that is, samples taken from the downtake show a gradual reduction of the "M" alkalinity extending over a period of an hour or more. Also the final "M" cannot be reduced to the low figure obtained with other waters. The "P-M" curve seems to be buoyed up. To illustrate, normally, we can reduce the final "M" to 35 to 40 p.p.m with a "P" of from 17 to 18. With these peculiar waters the minimum "M" will run 60 to 80 with a "P" of 28 to 38 p.p.m.

We note that this phenomenon obtains with waters running high in free CO_2, which appears plausible inasmuch as the CO_2 would oppose the lime reaction. We plan to provide for preliminary aeration as a demonstration and, if true, it will be the means of reducing the investment in softeners materially. Heretofore, filtration engineers have considered that the only way to handle such a problem is to provide for an excessive retention period.

Where such an excessive retention period is not available, we have relieved the situation materially by the use of sludge return; that is,

of re-circulation of sludge, mixed with the incoming raw water. This material, while not showing the presence of any appreciable unspent chemical, appears to speed up the lime reaction out of all reason. To illustrate, immediately before the introduction of the sludge, the lime treated water will show the "M" of 380 and a "P" of 180 p.p.m. The sludge will reduce the "P" to zero and the "M" to probably 180 p.p.m. Increasing the lime raises the "P" to 38 when the "M" will be reduced to 80 p.p.m.

Three explanations for this action occur to us. First, the additional stream discharged tangentially into the top of the downtake increases the agitation which is beneficial. The increase is marked, due to the gravity of the material. Second, the percolation of this material through the water acts as a catalyzer. Third, being mainly calcium and magnesium carbonate, it reacts with the CO_2 to form bicarbonate. While it is later broken down by the lime, the sludge does temporarily prevent the interference of the CO_2 with the lime reaction. By way of illustration, we picture an executive, representing the lime, trying to answer successfully the complaints of many callers, representing the CO_2, mulling around him. It helps materially for his efficient secretary, representing the sludge, to divert the attention of as many as possible until they can be separately considered.

In those batch softeners provided with air agitation during the liming period, we find that the air opposes the lime reaction to the point of entirely neutralizing its results. To illustrate, where the raw water has an "M" alkalinity of 180, a lime charge of $7\frac{1}{4}$ pounds will produce a "P" of 18- and an "M" of 38. Continuous air agitation will reduce the "P" to zero and restore the "M" to practically its original figure. The only plausible explanation is the CO_2 content in the air, negligible as it may appear to be. We cover this difficulty by by limiting the agitation from 10 to 12 minutes for the lime reaction and from 4 to 5 minutes for the coagulant mixing.

THE IRON REMOVAL PLANT AT ALBUQUERQUE, NEW MEXICO[1]

By F. M. Veatch[2]

The iron removal plant at Albuquerque, New Mexico, has now been in operation for a little over a year and seems to be handling a rather unusual water problem in a very satisfactory manner.

The treatment plant includes two mixing basins of the tangential flow type, in which the necessary agitation is afforded by the motion of the water itself, two settling basins, two filter units of the gravity type and chemical feeding equipment for lime, alum and chlorine.

The capacities of the various units, based on a normal flow of 5 m.g.d. are as follows: mixing basins, 10 minutes each; settling basins, 1.5 hours; filters, 874 square feet of filter surface, with control piping and valves arranged for operation at a rate of 4 gallons per square foot per minute, or approximately double the conventional filtration rate; clear water storage—only 200,000 gallons are provided at the plant since the city has 13 million gallons of storage in high level reservoirs.

The principal chemical treatment consists of the use of lime for the removal of carbon dioxide and iron as well as for partial softening, but a small amount of alum is used, as an aid to filtration.

Chlorine is not regularly used since numerous bacteriological tests have shown it unnecessary. Equipment for chlorination is set up in the plant and a supply of chlorine is kept on hand for emergency use.

A departure from the usual method of using aeration for carbon dioxide removal has been adopted here, since it was found that the additional lime required for this purpose is less expensive than the additional pumping head required for the operation of an aerator.

In routine operation lime is fed by means of a dry feed machine into one of the mixing basins. After mixing, the water flows to the

[1] Presented before the Rocky Mountain Section meeting, February 13, 1930.

[2] With Black and Veatch, Consulting Engineers, Kansas City, Mo.

settling basins when the greater part of the iron is precipitated. From the settling basins the water flows through a second mixing basin where a small dose of alum is added, and on to the filters. It has been found that the iron may be removed completely by the use of from 0.7 to 1 grain of lime and that sufficient floc for filtration may be obtained with from 0.1 to 0.2 grain of alum per gallon of water.

A limited amount of softening is possible with this plant and as a matter of fact from 10 to 15 percent the total hardness of the water is removed by the treatment given the water during the past few few months, which has consisted of 2.7 grains of lime and 0.2 grain of alum per gallon.

The water supply of Albuquerque is taken from five systems of wells, all of which are located within the city limits and tap what is probably the underflow of the Rio Grande River. The hardness and iron content of the water as well as the yield of the wells in the five systems vary widely, as shown in table 1. There also seems to be a trend toward increased hardness in most of the wells as shown by the difference in the results taken during July, 1926 and November, 1929.

Water of varying hardness can be obtained by using various combinations of these well systems as shown in table 2.

The production of softer water at this particular plant is largely a matter of selection. The use of so many varying kinds of water complicates somewhat the treatment problem. Frequent tests are necessary to determine the character of the raw water and the effect of treatment. These tests, which consist of alkalinity and permanent hardness determinations are made at Albuquerque daily, or oftener, if the raw water combination is changed and the chemical feed is checked at intervals of two hours. This record is kept on a daily log sheet together with the record of flow through the plant and filter record. The daily log sheets are summarized each month on a form which shows at a glance the total and average daily amount of water treated, the chemicals used and the effect of treatment.

The December operating record, for instance, showed that a treatment of 2.7 grains of hydrated lime and 0.2 grain of alum per gallon of water removed all of the iron and 42 p.p.m. of hardness (or 13 percent of total hardness) from the water at a cost for chemicals of $3.70 per million gallons.

TABLE 1

WELLS	DATE OF SAMPLE	HARDNESS, P.P.M.			IRON, P.P.M.	PROBABLE YIELD
		Alkalinity or temporary	Non-carbonate or permanent	Total		
						gallons per minute
Kent-Sturgis	1926	134	189	323	1.8	550
	1929	154	256	410	0.2	
Broadway	1926	127	285	412	2.9	200
	1929	126	316	442	7.0	
Mountain Road	1926	132	55	182	0.1	625
	1929	134	88	222	Trace	
5th & Mt. Road	1926	200	84	284	0.3	925
	1929	172	74	246	Trace	
Plant Wells	1926	145	52	197	0.6	500
	1929	138	172	310	Trace	

TABLE 2

WELL SYSTEMS IN USE	PROBABLE YIELD	HARDNESS, P.P.M.		
		Alkalinity or temporary	Non-carbonate or permanent	Total
	gallons per minute			
1. Broadway	200	126	316	442
2. Kent-Sturgis	550	154	256	410
3. Mt. Road	625	134	88	222
4. 5th & Mt. Road	925	172	74	246
5. Plant Wells	500	138	172	310
All wells	2,800	151	149	300
1, 2, 3, 5	1,875	140	187	327
2, 3, 5	1,675	141	171	312
2, 3, 4, 5	2,600	152	137	289
3, 4, 5	2,050	152	104	256
3, 4	1,550	156	83	239

This plant is operated by one man during the daylight shift, and during the night one of the pump house employees makes regular trips to keep the hoppers of the chemical feed machines full and to see that the plant is operating properly.

The city is at present prospecting for an additional supply and hopes to get a softer water. This seems possible since several such supplies exist. The Santa Fe, for instance, has three wells which furnish water with from 76 to 140 p.p.m. of total hardness and several of the laundries have similar supplies.

For a number of reasons it is advisable, in this case, to get a naturally softer water, than to attempt extensive softening of the present supply. In the first place, extensive softening entails additional expense for chemicals and requires that provision for longer settling and recarbonation be made in the purification plant. A large portion of the total consumption is used for irrigation in Albuquerque particularly during the summer when at least 50 percent of the total pumpage is used for this purpose. Softening to any great extent here, and this applies to many localities in the arid and semi-arid parts of the country as well as to Albuquerque, is not only wasteful of chemicals, but is actually detrimental to the water that is used for irrigation. For successful irrigation it is well known that the amount of calcium and magnesium salts in the water must exceed those of sodium and potassium. In Albuquerque this ratio is about two to one in the raw water, but if the calcium and magnesium are removed by the use of lime and soda ash, to the extent that the total hardness is reduced to 100 p.p.m., this ratio is about reversed and the water is unfit for use on lawns and gardens. In the western part of the country particularly, cities will do well to weigh the expense of obtaining soft water against that of softening plus the effect of highly softened water on their lawns and gardens.

As stated above, this plant has been succesful in the removal of iron and carbon dioxide and has gone about as far into the softening end of the game as is advisable.

IRON REMOVAL AT LA PORTE, INDIANA[1]

By C. C. Foutz[2]

The iron removal and purification plant at La Porte includes an aerating device consisting of 64 "Sacramento" type nozzles, discharging above a concrete "splash tray." The water flows to the center, whence it drops through a duct, nearly to the bottom of the aeration basin, which is a concrete reservoir 60 feet in diameter and 20 feet deep. The water rises in a diverging flow to a metal weir and conductor built around the basin and leveled to assure an equal flow at all points.

The effluent of this conductor enters a mixing chamber, containing 5 horizontal passes, and 30 vertical baffles which discharges into the settling basin. This is a concrete reservoir 100 feet in diameter and 24 feet deep, with a baffle wall extending nearly across in a center line, so that water passes nearly around the circumference to the effluent, which is a 24-inch cast iron pipe leading to the filters.

From the filters, water passes to underground storage reservoirs from which suction pipes emerge.

The two concrete reservoirs, referred to as the aeration and settling basins, were formerly used as storage reservoirs and their cost is not included in the iron removal plant beyond the work required to convert them to the uses of iron removal.

The "raw" water supply is pumped from the low duty station, 4½ miles from the city, directly through the aeration nozzles. The water flows by gravity from that point to the filtered water reservoir.

The "Sacramento" type nozzles have been very satisfactory, have been closed down, started and operated at 2 to 6 m.g.d. rate and from 90 degrees above to 22 degrees below zero, with no difficulty. Considerable interest has been shown by engineers in regard to their performance.

Alum is introduced at the center of the aeration basin at the rate of approximately 80 pounds to each million gallons. This produces a

[1] Presented before the Indiana Section meeting, March 20, 1930.

[2] Superintendent, Water Works, La Porte, Ind.

good floc and seems to give best results. This alum is fed through a "Gauntt" dry feeder and carried in solution through a hose to the point of use by means of a steam ejector.

The detention periods are: in aeration basin, 7 hours; in settling basins, 19 hours. This is based on normal operation of 4 m.g.d. The capacity of the aeration basin is 1,200,000 gallons, of the settling basin 3,140,000 gallons, and of the filtered water storage basin 1,500,000 gallons.

The water coming to the aerators varies greatly in iron content, and may be anywhere from 1.3 to 15 p.p.m. A typical colorimetric test for iron at the main points of operation is given in table 1. The aerated water is taken from the aerating basin near the effluent.

TABLE 1

Iron content in samples, results in p.p.m.

SOURCE	UNFILTERED	FILTERED SAMPLES (FILTER PAPER USED)
Raw	6	3
Aerated	4	1
Settled	2	0.6
Filtered	0.2	0.2

Table 1 indicates the proportion of iron removed by each operation. The filtered water shows 0.0 to 0.2 p.p.m. by daily test.

Four rapid sand filters are used, of 1 m.g.d. normal capacity. Each filter bed consists of 18 inches of gravel in 5 grades and 36 inches of silica sand. The beds are equipped with rate of flow and loss of head gauges, rate controllers, and hydraulic operated valves.

The filters are operated as near full capacity as possible. The average run on full load is 55 filter hours. The beds wash freely and at an average wash of 5 minutes at 4000 gallons per minute. A total of 20,000 gallons per wash cleans them in good shape. We have no filter problem, as the water is free from mud, silt, micro-organisms or growths, and only the iron is removed.

Wash water is supplied by a 40,000 gallon elevated tank, which is filled from distributing mains through a 4-inch service line.

The costs of the iron removal plant, with connections to the old pumping station are:

General Contract	$123,695.92
Engineering and Supervision	10,852.71
Contingent Costs	2,203.54
Total	$136,752.17*

* Or $34,175.53 per m.g.d. capacity.

The operating cost for 5 months ending January 31, 1929 were:

Operating labor	$701.40
Material and Supplies	813.07
Interest and Depreciation	2,647.45
Proportion of General Expense	460.00
Wash Water (Filtered)	115.41
Wash Water (Unfiltered)	56.00
Total	$4,835.55

TABLE 2

Results of chemical analysis, in p.p.m.

	MARCH 1, 1929	FEBRUARY 19, 1930
Odor	0	0
Color	0.15	0
Sediment	Slight	0
Turbidity	25	0
Nitrite	0.005	0.001
Nitrate	0	0
Total iron	1.3	0.2
Chloride	6	8
Alkalinity	220	230
Total hardness	314	242

Since 360 million gallons were treated, the cost was $13.43 per million gallons.

No full time labor is charged to iron removal, the duties of operation being distributed with steam pumping labor.

In comparing operating or production costs it should be remembered that these works are municipally owned, pay no taxes, or dividends. Only interest on bonds issued for this purpose is considered. All of these items would of necessity appear in a private or corporate owned property. The general expense is also very low, as office and other expenses are divided with other city departments.

The analyses by the Department of Chemistry, Indiana State Board of Health, and taken from reports by Mr. L. S. Finch, Chief Engineer of the Board, are shown in table 2.

The distributing mains and service pipes were extremely foul with iron deposits. Advantageous results began to appear immediately on starting the removal plant and the pipes cleared much more rapidly than anticipated and are now practically free from iron deposits, with the exception of valves and dead ends, which infrequently release small amounts of iron sludge, which appear locally for short periods. The "red water" nuisance, however, has been overcome and the reaction of the consumers has been all that could be asked for. Even the "Doubting Thomases," of which we, of course, have our share, now admit the success of the operation.

The engineers for this work were Hoad, Decker, Shoecraft and Drury of Ann Arbor, Michigan. The plant was designed under the supervision of R. L. McNamee, Principal Assistant Engineer, Mr. Ralph Ehler, Staff Engineer of the same firm was Resident Engineer and Inspector on the construction.

MUNICIPAL WATERSHEDS IN THE NATIONAL FORESTS OF MONTANA[1]

By M. H. Wolff[2]

In this state there are 30 communities of one hundred population or over, which depend for their water supply in part or wholly on watersheds which are part of the National Forests. The aggregate population of these communities is over 150,000. These communities averaged over 40 million gallons used daily. Their water-works represent an investment of close to $11,500,000.

The aggregate acreage of the watersheds is over 2,700,000 of which close to 75 percent is National Forest land, the other 25 percent being either outside the National Forest boundaries or private owned lands within. There are certain policies and principles in the handling of these National Forest lands and their resources which are undoubtedly of interest to members of the American Waterworks Association.

These watersheds contain Government owned resources of considerable magnitude. The timber aggregates close to 4 billion feet board measure with a value of $4,600,000. The counties have an equity of over $1,100,000 in this since under the law they get 25 percent of the gross National Forest receipts to be used for roads and schools. Something under 10 million feet per year is now being utilized. The future promises much greater utilization; probably over 60 million feet per year can be produced from the Forest lands.

The grazing resource is capable of carrying about 19,000 cattle for an average period of four and one-half to five months and about 95,000 sheep for about three and one-half months. The market value of this grazing resource totals roughly around $1,500,000. At present in the various areas about 360 permittees are concerned, with 18,200 cattle and 77,500 sheep. The annual potential grazing fee return based on present rates is $21,000. The counties have over $5000 interest in this.

[1] Presented before the Montana Section meeting, April 19, 1930.

[2] Assistant District Forester, United States Forest Service, Missoula, Mont.

The recreation benefits are estimated by the supervisors to be capable of 300,000 man-days of pleasure; at present the actual use is 160,000 man-days, not far from one-half year straight for 1000 people.

Within these watersheds are other potential uses. There are doubtless many undeveloped mineral deposits that are yet to be disclosed. In many instances there are promising water power development possibilities. There are many locations for reservoirs for irrigation. Opportunities for summer homes and resorts are legion.

There are two essential requirements for a water source. First, there should be an adequate supply at all seasons of the year; and secondly, the supply should be as pure as possible.

The practices necessary to keep forest lands productive of timber, grass, and other beneficial returns, are adequate to maintain the maximum possible water flow as well as the optimum distribution of that flow throughout the year.

For insuring purity, the first thing that occurs to a layman, is to close the watershed to human occupancy. I believe there is considerable room for questioning the wisdom of such closure in most cases. Several considerations argue against it:

There would result the locking up of valuable timber bodies. This would mean not only direct revenue losses to the Federal Government and to the counties, but even a greater actual or potential loss to local industries, logging and milling. It has been at various times estimated that every thousand board feet of cut, brings $20.00 into the community in payment for wages and supplies. In many localities it means the complete driving out of business of small millmen and loggers. In quite a number of instances it would mean that ranchers would have to go farther to obtain their farm needs and at greatly increased inconvenience.

Probably the greatest immediate injury would be to grazing use. In practically every case the 400 permittees are dependent upon the range as their mainstay for a livelihood. It balances their winter-forage producing farm lands. The possibility of obtaining other range in case this should be closed is rather exceptional. Closing the area would mean considerable hardship to most of the 400, and would greatly diminish the total output of livestock from their properties, and thereby greatly reduce their value. In many instances it would mean the actual closing up of farm homes.

Closing these areas to human occupancy would have a serious effect upon recreationists. Accustomed to visiting most of these areas freely, they naturally would view the closure with considerable resentment.

Possible mineral and water power developments would be locked up. Other forms of beneficial land use would be precluded.

To control human use properly would mean a considerable increase in the cost of patroling many of these areas. Someone, whether the municipalities or the state, would have to underwrite this additional charge, roughly estimated at over $50,000. It should scarcely be expected that the Government should undertake this cost.

On the other hand, in but very few cases will such closure be of any material help. Some 25 percent of the aggregate watershed area in Montana is already privately owned. Many of the watersheds have a much higher percentage. Much of this 25 percent is farm land and occupied. Even if the Government lands were closed, this major source of menace would still continue. The privately owned timbered lands will be logged sooner or later, and there would be an additional source of trouble.

Sanitarians, including the Public Health Service, assure us that restricting the use of the area by humans is not an absolute safeguard. For real safety the water should be treated anyway, despite some idea, however, that the purer the water, the less proportion of disinfectant or chemical need be added.

The need of special efforts in municipal water sheds has long been recognized by the Forest Service. Reg. L-11 of the Secretary of Agriculture shows the Departmental view.

"When necessary for the protection of water supplies of towns, cities, or irrigation districts, the Secretary of Agriculture will enter into formal agreements with the properly authorized officials of the town, city, irrigation district, or private corporation, or with the owners of privately owned lands within the watershed, to restrict the use of the national forest lands from which the water supplies are derived. The forms of use to be restricted, the nature and extent of the restrictions, the special protective measures which may be necessary or desirable, the assistance to be given the Forest Service in the enforcement thereof by the town, city, district, private corporation, or owners of land, and the payments, if any, which shall be made to compensate the United States for losses of revenue resulting from the restrictions, will all be clearly and specifically defined in the agreement."

The fundamental principle, you will note, is to take all reasonable special precautions without penalizing the general public to an unwarranted degree. The Department is anxious to do all it can to protect the purity of municipal waters, but is also concerned with its responsibilities as steward of the nation's national forests to put all lands to highest beneficial use.

The Government is anxious to coöperate in every feasible way with state and municipal authorities. At the same time it cannot subscribe to any demands which are not equitable, or can be shown to be rather the opposite. Government officers are not authorized to penalize federal owned resources to an inordinate and not reasonably justified degree. These resources cannot be locked up for a limited benefit. And the owner public—generally and locally,—is entitled to consideration. Especially would these lock-ups be unwise, if after that there would not be any assurance of protection, by reason of considerable privately owned lands and related resources over which there would be no control and which would continue to carry the liability of considerable menace.

There are numerous examples of what has been done by the Forest Service on municipal watersheds in the National Forests. Planting projects on municipal watersheds are given priority. Special fire protection efforts are made. Close to $350,000 has been spent by the United States in municipal watersheds of Montana on roads, trails, telephone lines, etc., primarily valuable for fire protection. In addition, where it is not feasible or of much value to restrict the use by the public, the Forest Service has pushed along the development of public campgrounds so located and with the improvements so constructed, as to reduce to a minimum the danger of pollution of the water. In all contracts, agreements or permits for timber use or forage use or land use, strict precautions have been required in such matters as distance of camps from flowing streams, compliance with the state sanitary regulations in every regard, and the establishment of minimum distances for the bedding of sheep. Formal or informal agreements with local municipal offices have been fostered with the object of coöperating in patrol and in the construction of drift fences to protect important sources of water supply and in encouraging the municipal officers to obtain agreements with other owners in the watersheds to handle their lands carefully. The Government has given priority to the acquisition of private lands in municipal watersheds through the authority of the Land Exchange Act.

The Government's position is that closing a watershed to all forms of economic use just because it supplies municipal water is not always necessary or wise. That may not result in the greatest net benefit to the public. The treatment of water is often, if not always, essential anyway. In spite of public demands, unless those public demands are based upon informed and intelligent analysis, absolute closing of watersheds is not favored. You all, of course, know that there is plenty of support for this among opinions of experts.

From a letter of an Assistant Surgeon General of the U. S. Public Health Service, written within the last five years, I quote interesting passages.

"Water-works people are in most instances cognizant of the fact that it is almost impossible to deliver a pure and satisfactory supply under present day conditions, unless some artificial purification process is used, but nevertheless it is assumed by them that the bacteriological load on such purification should be held at a minimum.

"As long as there is no large and extensive project which will benefit a great number of people contemplated for an area . . . . there seems to be every reason for permitting its closure. Such closing, however, does not warrant a city furnishing a water which is not at least disinfected, for the tightest closing of watersheds will not always exclude all sources of water contamination."

I think it is in the Manual of your association published in 1925, that this sentence appears. "The tendency appears to be away from a dependence upon preventative measures on the watershed in lieu of purification processes in the intake."

The Government's efforts are not infrequently nullified through the presence of privately owned, occupied lands in the drainage. Obviously it would be fruitless to close the Government's lands in an area like the Rattlesnake Creek out of Missoula, for instance, so long as ranches existed. The watershed for the town of Helena, has also considerable private lands. The sources or pollution on private lands would first have to be eliminated. Frequently this can be accomplished only at prohibitive cost. It is then better to leave the lands and associated resources in use and to elaborate instead on mechanical or artificial water purification.

I do not want to be misunderstood as against any closure whatsoever, anywhere. The Government's position in this point is perhaps expressed by again quoting from the Assistant Surgeon General. He says "Each water supply must be an individual problem in the

determination of the policy to be followed and the economics of each case must be given an important place when considering a proper balance between the installation of a purification apparatus and the exclusion or closing of a watershed." In some cases, putting lands to their highest use, may mean closing them to human occupancy to safeguard water supples. In other cases, a partial closing may be justified; for instance, promiscuous public picnicking and camping might be entirely prohibited, but the removal of the mature timber growth once every thirty to fifty years, in operations lasting for only one or two seasons might be clearly justified.

There are numerous examples that can be given. It would be wholly uneconomic for instance to close the Boulder River from which the town of Big Timber with its 1800 people gets its water supply. There are 180,000,000 feet of Government timber in this drainage area worth at least $180,000. The grazing resources are worth over $150,000 and bring in close to $2000 in annual fees. Twenty-thousand-man-days recreation are provided in this drainage. At best, if all these uses of Government resources were eliminated, there would still be a dozen or more dude ranches and resorts located on private lands where many visitors congregate. These would be purchasable at rather prohibitive costs. The locking up of the economic resources and the expenditures for these ranches would appear to be a greater sacrifice economically than the extra expense of purifying the water at the intake.

The water supply of the town of Anaconda is in a similar category. Warm Springs Creek is close to 30 percent on privately owned land. It carries a volume of Government timber estimated at 83,000,000 feet with a value of over $133,000. The value of the forage is over $65,000. Some forty or fifty thousand man-days recreation are provided. An important highway passes through, adding difficulty to closing. It seems far more economical to leave this watershed open and to chlorinate the water supply as the city now does.

On the other hand there are some drainages like that of Ashley Creek serving Thompson Falls that could, if desired, be closed to everything except occasional removal of timber products without any out-of-balance sacrifice of material quantities of economic resources.

Authority already exists for the Secretary of Agriculture to control National Forest land use. However, to strengthen his powers and particularly since National Forest lands are subject to entry under the mining laws, new legislation has been proposed to extend the

authority of the Department. I understand the Department has recommended favorably on Bill S. 484 introduced by Senator Norbeck of South Dakota in the 71st Congress. This is "to provide for the protection of watersheds within the National Forests which area is a source of a municipal water supply." This bill provides first, authority to the Secretary of Agriculture "upon formal request for such action of a municipality, to promulgate such additional recommendations as he deems necessary;" secondly, it empowers the President of the United States upon concurrence by the Secretary of Agriculture and the Secretary of the Interior and after a public hearing has been conducted in regard to the matter, to withdraw watersheds from all forms of public land entry; and thirdly, it authorizes the Secretary of Agriculture to enter into coöperative agreements with municipalities for periods not exceeding 25 years defining the mutual obligations in cases where protective measures on National Forest lands will require expenditures in excess of the ordinary, or will withhold National Forest resources from utilization or sale.

Concretely, the Department's attitude is expressed in the following section, which is required to be inserted in all coöperative watershed agreements with municipalities:

> (*a*) First, that the Department of Agriculture will not authorize, by permit or otherwise, any use of said lands under conditions which, in the opinion of the proper State or Federal authorities formed after due study and investigation, will diminish, pollute or contaminate the water supply of the City of ———— to a degree detrimental to public health or safety and not practically remediable by means other than the closure of said lands to such use or occupancy; but the Secretary of Agriculture may adopt and apply measures for the proper care and protection of the forest; the marking, cutting and disposition of such timber as, in the judgment of the Forest officers, may be removed without injury to the water supply of said city; the construction of roads, trails, telephone lines and other means of transportation and communication not inconsistent with the objects of this agreement; and for rights of way or other rights or interests acquired or established under specific Acts of Congress.

The Forest Service is willing and anxious to coöperate in the matter of municipal water supplies to the fullest possible degree. It believes that uses of the National Forest resources and lands should be restricted or eliminated only where benefits surpass economic losses and administrative complications,—and that, only after careful adequate and comprehensive study by the proper State or Public

Health or other sanitary authorities has established the need for such closure. Having before it the ideal of all lands put to their highest use, the Forest Service is not ready to enter into sweeping agreements with municipalities which will require the holding of large areas in a condition of practical nonuse, unless the need of doing that has been definitely determined after thorough scientific study in which all conflicting uses of the area have been carefully weighed against each other.

THE WATER SUPPLY SYSTEM OF KANSAS CITY, MISSOURI[1]

By T. D. Samuel, Jr.[2]

The history of the public water supply of Kansas City, Mo., begins in the year 1873 when the National Water Works Company of New York City was granted a franchise to operate a water works system. By 1875 the city was being supplied with water through about 12 miles of mains and the total capacity of the company's works amounted to approximately 4 m.g.d. The pumping machinery was located in what is still known as the Turkey Creek Pumping Station situated at 25th and Fairmount Street. Water was drawn from the Kaw or Kansas River through a 24-inch cast iron pipeline.

The Turkey Creek Station was equipped with settling basins in which the water was allowed to settle, no other method for purifying being used. From there it was pumped to a reservoir known as the Holly Street Reservoir located in what is now Observation Park. It had a capacity of about 9 million gallons and was approximately 170 feet above the Turkey Creek Station. The entire town was supplied by gravity from this reservoir, which is still in service, supplying by gravity the West Bottoms or Central Industrial District.

Such was the system that gave Kansas City its first public water supply.

As time went on the water in the Kansas River became more or less polluted and thoroughly unfit for drinking purposes and in 1886 the source of supply was changed from the Kansas River to a point on the Missouri River near the old town of Quindaro in the State of Kansas, approximately six miles up the river from the city.

In the year 1895 the city purchased the water works system from the National Water Works Company of New York City for the sum of $3,100,000, issuing 4½ percent bonds against this debt. The entire amount of bonds issued by the city for use of the water works since its purchase amounts to $17,525,000, and the cost of all exten-

[1] Presented before the Missouri Valley Section meeting, October 2, 1928.

[2] Chief Engineer and Superintendent, Water Department, Kansas City, Mo.

sions and the improvements has been paid out of the earnings of the department, with the exception of these bonds. Today the plant is valued at a sum of $22,504, 686.64.

The enormous growth in the system since being taken over by the city in 1895 is shown by the following data:

	1895	*1928*
Population supplied	130,000	433,000*
Average daily consumption, gallons	9,340,000	56,296,000
Maximum hourly consumption, gallons	12,000,000	78,200,000
Number of water services	12,760	87,920
Miles of mains	112	770
Fire hydrants	1,349	9,650
Collections per annum, dollars	267,225.0	2,156,479.33

* Estimated.

The water department furnishes water free for fighting fires, cleaning streets, flushing sewers, public buildings, public bath houses and swimming pools and for all park and boulevard purposes. This amount of free water it is estimated would, if paid for at the present rate, amount to approximately $300,000.00 per annum.

Kansas City supplies water to suburban districts, including the towns and cities of Sugar Creek, Independence, and indirectly to Lee's Summit, which in turn is supplied through Independence, Raytown and that district lying west of the state line in Kansas south of 48th Street. There are several connections along the state line between the Kansas City, Mo., and Kansas City, Kas., systems whereby Kansas City, Kas., can be supplied in case of an emergency. Eighty-six percent of all services are metered.

ORGANIZATION

The management of the water works is under the control of a Director appointed by the City Manager. The Department consists of three divisions, namely:

Division of Administration under the direct management, supervision and control of the Director. The work of this division includes all matters of general administration and cost accounting.

Division of Engineering. This division is in charge of an officer who is known as the Chief Engineer and Superintendent. He has charge of purification, pumping and distribution of water, construc-

tion, reconstruction, extension and repair of the water works system.

The Division of Collections. This division is in charge of an officer known as the Commissioner of Water Collections. He has charge of meter readings, inspection of meters and house services, the computation of charges for water service, the collection of all charges for water service and the keeping of records thereof.

For expediency in billing water accounts, the city is divided into four districts. These four districts are billed bi-monthly. The larger domestic and industrial consumers are billed each month. The flat rate consumers are billed every three months. A charge of $1.00 per month is made for fire protection services.

SUPPLY SYSTEM

Kansas City's supply system consists of the old source of supply at the Quindaro pumping station; pressure flow lines from that station to an equalizing reservoir at the Turkey Creek high lift pumping station; the new East Bottoms high lift pumping station; the new supply works just north of North Kansas City, Mo.; pressure tunnels and a steel pipe line from that source to equalizing reservoirs at the Turkey Creek and East Bottoms stations; the distribution system containing 770 miles of mains ranging in size from 2- to 42-inch; two distributing reservoirs of 16 and 9 m.g. capacity; two booster districts in which the pressure is increased by means of motor operated centrifugal pumps and a standpipe district supplied through a one million gallon reinforced concrete standpipe.

At the old supply works at Quindaro which is to be abandoned in the near future, water is taken through an intake on the right shore of the Missouri river and pumped into a series of settling basins. There are five basins in all with a total capacity of 90 mlllion gallons, the final or finished water basin having a capacity of 45 million gallons. Lime and alum are introduced into the water for sedimentation and coagulation purposes as it passes over weirs from one basin to another. The water is disinfected with chlorine gas as it is drawn from the final basin for pumpage over to the high pressure station in the city.

There are seven steam driven centrifugal pumping units in this station, two of them being piped in such a manner that they can be used for pumping either from the river to the basins or from the basins to the city. The total pumping capacity from river to basins

amounts to 135 m.g.d., while that to the city amounts to 105 m.g.d. At this station we have an alum manufacturing plant. All alum used in treating water is manufactured by the department under the Hoover process. The station is equipped with seven horizontal water tube boilers of a total capacity of 2100 H.P. Oil is used as fuel.

Water is pumped from this station to the city through three pressure flow lines, two 48- and one 36-inch, approximately 18,000 feet to the west bank of the Kansas river. From there it passes under this river through a 6-foot 6-inch brick line tunnel 1,125 feet long to the south shore of the river. From this point it is carried approximately 14,000 feet through two 48- and two 30-inch lines to the Turkey Creek high lift station, and from there distributed throughout the city.

The Turkey Creek station is a high lift steam operated station operating under a steam pressure of 165 pounds and pumping water to an elevation of 390 feet above city datum. The boiler room is equipped with ten horizontal water tube boilers with a total capacity of 4,000 H.P., eight of these boilers being operated with traveling chain grates and two with pulverized coal burning equipment. Coal is used as fuel, but the two boilers operated with pulverizers are also equipped with oil burners. A traveling weigh lorry is used in conveying coal from an outside overhead coal bunker to the hoppers on each boiler. There is also a submerged coal storage pit with a capacity of a 90 day supply adjacent to the boiler room. Coal is unloaded from cars into the storage pit or directly into the overhead bunker by means of an oil burning locomotive crane with a 70-foot boom.

A complete machine shop capable of handling all machine work for the entire department is maintained at this station.

The engine room is equipped with one 20 m.g.d. Allis Chalmers horizontal double acting Reidler pump, two Allis Chalmers 15 and 20 m.g.d. vertical triple expansion pumps, one William Todd 20 m.g.d. vertical triple expansion pump, one DeLaval 20 m.g.d. steam turbine driven centrifugal pump and one Worthington 30 m.g.d. steam turbine driven centrifugal pump—all having a total pumping capacity of 125 m.g.d.

Water is received at this station from Quindaro in an equalizing reservoir consisting of 5 basins having a total capacity of 12 million gallons.

DISTRIBUTION SYSTEM

The distribution system consists of pipes ranging in sizes from 2- to 42-inch and is practically all constructed of cast iron. Some of the newer and larger discharge lines immediately adjacent to the Turkey Creek station and the new East Bottoms station are constructed of steel and one of the 48-inch pressure flow lines from Quindaro to the Kaw river tunnel and the new East Bottoms 54-inch supply line are constructed of steel.

Although frost seldom penetrates to a greater depth than three feet, all mains and services are laid with four feet covering.

The average total cost per foot for installing mains, including valves, hydrants and specials, in all classes of excavation amounted for the last fiscal year to;

Size, inches.....	6	8	10	12	16	24	36	42
Cost per foot, dollars	2.42	3.49	3.72	5.65	9.54	20.02	30.22	54.34

Hydrants are spaced 300 feet apart in the residential districts and in the congested and business districts much closer. Gate valves are placed on all new hydrants and are gradually being installed on old hydrant connections. All main cross connections are valved and valves are installed on smaller lines approximately 600 feet apart. The larger feeder lines are valved each quarter mile. There is a total of 12,666 gate valves and 9,760 fire hydrants in service in the system.

Some years ago the city adopted a policy of purchasing and installing all meters, the meters remaining the property of the city. However, this practice was discontinued and at present the consumer furnishes at his expense the meter of whatever size. All meters are tested and set by the department at the expense of the consumer. All repair costs are also paid by the consumer. Meters are set in tile boxes at the curb and in basements.

A number of years ago the city adopted a standard hydrant in accordance with plans drawn by the department. Patterns owned by the city are furnished to local foundries and the rough cast iron and bronze castings are made by them. The finished work is done by the department's forces in the machine shop at the Turkey Creek station. Assembling of the hydrants is done by our mechanics at the pipe line division's station at 40th and Mill Streets.

The city is divided into seven districts known as valve and hydrant districts. To each district is assigned a valve and hydrant crew and

it is the duty of these crews to make scheduled inspections of, and to maintain and keep in operating condition all valves and hydrants within their respective districts. Additional men are also assigned in winter weather for regular inspection of all hydrants. Hydrants found frozen are reported immediately and a special crew with a specially constructed gasoline burner are sent to thaw out the hydrant and place it in operating condition. Hydrants used for fighting fires are inspected immediately after the fire and placed in operating condition. The department is notified by fire headquarters of all fire alarms and in case of large fires, crews from the department are in attendance. No increase in pressure is made at the pumping stations for fire fighting purposes.

For convenience in construction purposes the department has located in scattered sections of the city four sub-stations. One is the headquarters of the pipe line or construction division and main garage. The other three are used as pipe and material yards. One of these three is used as the headquarters for the meter division, storage space for meters and a meter repair shop.

Within the city there are two open distributing reservoirs. One, located in the northeast section of the city at St. John and Wabash Avenues is a reinforced concrete structure having a total capacity of 16 million gallons, and is used to supply the East Bottoms district by gravity. The other is a reservoir constructed many years ago at 20th and Holly Streets, has a capacity of 9 million gallons and is used to supply the West Bottoms district by gravity. Both of these basins are filled at night during the off peak hours of the Turkey Creek and East Bottoms pumping stations.

There is a district lying in the extreme southern and southwestern section of the city known as the Standpipe district, the highest point of which is 304 feet above city datum. Within that district there is located a one million gallon reinforced concrete standpipe, 40 feet inside diameter, 110 feet in height to the extreme high water level line and with a total height, including superstructure, of 134 feet. This standpipe is operated automatically by means of an altitude valve, and it is so connected to the distribution system that, as the pressure from the Turkey Creek and East Bottoms high lift pumping stations rises, the tank will fill, and when the pressure drops, water flows out to be distributed over the standpipe district. Water is prevented from flowing out of the district by means of check valves installed on all lines entering into the district.

NEW SUPPLY WORKS

The new supply for Kansas City is not, strictly speaking, an entire new supply, but is an addition or enlargement of the existing plant. The new works will supplant the old Quindaro pumping station, intake basins and pressure flow lines.

The new supply system consists of an intake and purification works, just recently completed and placed in partial operation, and located just north of North Kansas City, Missouri, on the left bank of the Missouri river approximately five miles due north of the city.

Water is taken from the river at this point, purified and delivered through the Missouri Valley tunnel to Front and Wyandotte Streets, where it branches, one portion going through the Turkey Creek tunnel to the Turkey Creek high lift pumping station at 25th and Fairmount Streets, and the other portion passing through a 54-inch steel line to the new East Bottoms high lift pumping station.

A condensed description of the new plant follows:

Intake

The substructure of the intake is constructed of massed reinforce concrete, 52 feet long by 35 feet wide with a concrete base 11 feet thick on 60 foot timber piles. The superstructure is of brick masonry and steel. It is equipped with Link-Belt traveling screens and an overhead traveling crane and has a capacity of 150 m.g.d.

There are 6 ports for taking in the water, each 8 feet high and 9 feet wide, arranged in two rows of three each. The intake is heated electrically. It is protected by standard willow mattress and rock paving.

Low Lift Pumping Station

This building is located approximately 150 feet inshore from the intake. The substructure is 102 feet long by 36 feet wide, constructed of reinforced concrete on 40 foot timber piles. The superstructure is of brick masonry and steel. The station has a capacity of 140 m.g.d. and is equipped with four 35 m.g.d. motor driven centrifugal pumps with provision made for future installation of an additional pump. The station is connected to the intake with four 38-inch steel suction lines.

Preliminary Settling Tanks

Water is discharged from the low lift pumping station through two 60-inch steel lines 1400 feet long into four circular preliminary settling

tanks, each 200 feet in diameter, constructed of reinforced concrete on reinforced concrete piles. Each tank has a capacity of approximately 4 million gallons and is equipped with Dorr clarifying mechanism for the reduction of suspended matter in the water. Water enters these tanks through baffled influent weirs at the top of the tanks and is discharged through effluent weirs, also at the top, and on the circumference of the tanks.

Mixing Tanks

Water passes from the preliminary tanks through steel pipe lines to two circular mixing tanks. These tanks are constructed of reinforced concrete on concrete pile foundations, are 90 feet in diameter with a capacity each of one million gallons. The first application of lime and alum is made at the mixing tanks, the mixing effect being obtained by introducing the water into the tanks tangentially at the circumference and discharging it at the center of the bottom. The water passes from the mixing tanks to the coagulating basins through 3 reinforced concrete conduits and is discharged into these basins through a series of 30- by 30-inch submerged sluice gates.

Chemical Building

The chemical building is adjacent to the mixing tanks and is 45 feet wide by 150 feet long, the substructure being of reinforced concrete with concrete pile foundation. The superstructure is of brick masonry and steel. Alum is manufactured in this building by the Hoover process. Lime and alum solution tanks with motor driven mixing equipment are installed in this building. A storage capacity of over two weeks supply of lime and alum during continuous peak operation is provided for. This building also houses the central heating plant which heats all buildings in the purification works with the exception of the intake and the low lift station, which are heated with electricity.

Coagulating Basins

There are three coagulating basins, each 333 feet long by 309 feet wide by 18 feet deep constructed entirely of reinforced concrete and with a total capacity of 37½ million gallons. Water is discharged over weirs from the three coagulating basins into two final basins. The two final basins are each 359 feet long by 254 feet wide by 17 feet

deep and have a total capacity of 14½ million gallons. The water passes from the final basins to the filtration plant through concrete conduits.

Filtration Plant

The filtration plant is constructed of reinforced concrete, the superstructure of brick and concrete, is 200 feet wide by 250 feet long and consists of 24 filter units of 4 million gallon capacity each. The bed of each filter is composed of 27 inches of sand and 18 inches of gravel. The strainer system is constructed of wrought iron. A controller system to control the wash water while the filters are being washed is installed in the filter plant.

Wash Water

A supply of wash water for washing the filters is provided in two steel storage tanks, each of 75,000 gallons capacity, just west of the filtration plant. Water is pumped into these tanks by three 2,500 gallons per minute centrifugal pumps installed in the secondary pumping station.

Pressure Water

Water at 80 pounds pressure for general use about the plant is supplied from a 75,000 gallons steel tank on the hill north of the purification works. Water is pumped into this tank by two 250 and two 500 gallons per minute motor driven centrifugal pumps located in the secondary pumping station.

Chlorine Building

This building is about 50 feet west of the secondary pumping station and is 35 feet long by 21 feet wide, the substructure constructed of reinforced concrete on concrete piles, and the superstructure of brick and reinforced concrete.

The Wallace and Tiernan system of chlorination is used, with a maximum capacity of 600 pounds per 24 hours. Two chlorinators, each of a capacity of 300 pounds are installed with provision made for doubling this capacity in the future. Chlorine is delivered through rubber hose to a point in the suction conduit of the secondary pumping station just ahead of the main pumps.

Secondary Pumping Station

This building adjoins the filtration building on the south. It is 165 feet long by 45 feet wide with a reinforced concrete substructure

and a brick and steel superstructure. There are four 35 m.g.d. motor driven centrifugal pumps installed with provision made for the future addition of one pump. Water is drawn from a clear well under the filters by these pumps and discharged into a header system, which in turn discharges into a 72-inch steel pipe line leading to the shaft of the Missouri Valley tunnel located about 500 feet south of the pumping station.

Missouri Valley Tunnel

The entrance or downtake shaft of this tunnel is circular, 10 feet in diameter and 280 feet deep and is lined with concrete. The first 107 feet of the shaft were sunk through water bearing sand and gravel by the pneumatic caisson method. The remaining 173 feet were sunk through rock by the open method.

The Missouri Valley tunnel is circular, 7½ feet in diameter and 15,500 feet long. It is on a level grade from the downtake shaft to the uptake shaft at Front and Wyandotte Streets. The tunnel is in rock or hard shale approximately 280 feet below the ground surface and is lined with concrete that averages over 8 inches in thickness. The economic carrying capacity of the tunnel is 150 m.g.d.

The uptake shaft, at Front and Wyandotte Streets, is of the same construction as the downtake shaft with the exception that its entire depth is through rock.

Turkey Creek Tunnel

Water rises in the uptake shaft of the Missouri Valley tunnel and passes through valve controlled cast iron lines to the downtake shaft of the Turkey Creek tunnel. This downtake shaft is located 50 feet west of the Missouri Valley tunnel uptake shaft and is circular, 8 feet in diameter and 140 feet deep. It is lined with concrete and is constructed entirely through rock.

The Turkey Creek tunnel is circular, 6 feet in diameter and 11,000 feet long. It is in rock and lined with concrete averaging over eight inches in thickness. It is approximately 140 feet below the ground line and is on a level grade.

The uptake shaft is on the grounds of the Turkey Creek high pressure pumping station. Water rises in this shaft and is discharged into the Turkey Creek basins through a 66-inch steel pipe line approximately 350 feet long. Discharge into the basins is controlled by Larner-Johnson pressure reducing valves. This shaft is of the same

construction as the downtake shaft with the exception that the first 70 feet was sunk through sand and gravel before reaching rock.

East Bottoms Flow Line

Water passes from the uptake shaft of the Missouri Valley tunnel into a flow line, to the new East Bottoms high lift pumping station. This pipe line is 54 inches in diameter, about 15,000 feet long, and is constructed of $\frac{1}{16}$-inch riveted steel dipped in one coat of Hermastic coating at the shop. This flow line discharges into the equalizing reservoir alongside the East Bottoms pumping station and is controlled by pressure reducing valves of the Larner-Johnson type operated from the station.

New East Bottoms Equalizing Reversoir

This reservoir is a covered structure of reinforced concrete 380 feet by 345 feet by 18 feet deep, and has a capacity of 17 m.g.

New East Bottoms Pumping Station

This is an electrically operated station. The main building is 52 feet by 92 feet with a switch house 50 feet by 28 feet. The substructure is of reinforced concrete on concrete piles with a brick and steel superstructure. Two 24 m.g.d. motor driven centrifugal pumps are installed in the pump room with provision made for the addition of one future pump. The station is heated by an oil burning plant.

The discharge main from this station is a 42-inch steel line approximately 6,000 feet long to where it connects with the distribution system. It is a $\frac{5}{16}$-inch riveted steel line, tested to 200 pounds pressure and is coated with one coat of Hermastic.

GENERAL

The entire new supply system is operated electrically. Exclusive duplicate power feeders originating at the Kansas City Power and Light Company's Northeast station supply the East Bottoms station and the purification works at North Kansas City. The plant is built on the unit scale and can be added to as required.

The cost of the new works, tunnels, feeder mains within the distribution system and improvements at the old station will total $11,000,000.00.

The new supply system has an average daily capacity of 100 million gallons, and an overload capacity of 125 m.g.d. It is expected that this capacity will meet the requirements of the City until 1942.

WATER FILTRATION PLANT AT SHEBOYGAN, WISCONSIN[1]

By Charles B. Burdick[2]

The following paper briefly describes the plant now under construction at Sheboygan, Wisconsin, for filtering the city water supply from Lake Michigan. This plant has a rated capacity of 12 million gallons per twenty-four hours.

The Sheboygan water works is located on the lake shore in the northern part of the city and adjoins Vollrath Park. The present pumping station, built many years ago, but added to from time to time with the growth of the city, has drawn its supply by suction and pumped it into the city mains against direct pressure.

The filtration plant now under construction, adjoins the pumping station upon the south and occupies the top and slope of a clay bluff rising to a maximum height of 48 feet above the lake. A portion of the plant is built directly upon the beach and protected by a suitable break water. The new plant includes a low lift pumping installation taking water from the old intake shaft and discharging it through mixing tanks, coagulating basins and gravity mechanical filters into a clear water reservoir occupying the space beneath the filters and with an extension forming a covered reservoir accommodated on what was the beach of Lake Michigan.

POPULATION AND WATER CONSUMPTION

The present population of Sheboygan is approximately 40,000.

During the past fifteen years, the pumpage has grown from 3.3 to 5.6 m.g.d. At the present time, 47 percent of the consumers are metered. During the past year, pumpage rates were as follows:

	m.g.d.
Average 24 hours	6
Greatest 24 hours	9.4
Peak rate, greatest hour	19

[1] Presented before the Illinois Section meeting, April 23, 1930.

[2] Alvord, Burdick and Howson, Engineers, Chicago, Ill.

The plant capacity of 12 million gallons, supplemented by 1,750,000 gallons in clear water storage, is estimated to be sufficient for present requirements and to allow for a moderate future growth.

In adding filtration to the existing pumping operations, it seemed desirable that the two should be closely coördinated so that the operations of pumping and filtering could be carried on with a minimum labor force. The plan as laid down contemplates future construction in units in order that the plant may be extended to accommodate the future growth of the city.

The plant throughout is built of fire proof construction, there being no wood about the plant except in window frames and doors. An effort has been made to build a plant of good appearance. It is believed to be a good business policy for a water board, ably and economically conducting its affairs, to have a proper regard for appearance in the structures built. The greater part of any investment is necessarily buried beneath the ground. The public is likely to judge as to its excellence by the small part of it that is visible.

DETAILS OF PLANT

A new break-water consisting of a double row of piles supporting steel sheeting 20 feet long and extending 6 feet above the normal lake level, protects the site of the new plant. The length of shore line protected is about 400 feet. Break water construction is supported by anchor piles and steel rods buried beneath the terrace which adjoins the clear water reservoir on the lake side thereof. The bottom of the clear water reservoir is located one foot above normal lake level. This reservoir contains 20 feet of water. It has vertical sides and a flat reinforced concrete roof covered with one foot of earth and sodded.

Filters are superimposed on the top of the westerly end of the clear water reservoir. Coagulation basins and head house containing chemical storage facilities and laboratory are located on the gradually ascending ground on the slope of the bank of the Lake with only moderate depths of cutting. The different parts of the plant are thus arranged at elevations suitable to carry the water through the plant with no unnecessary head losses.

The filter plant building is connected to the present pumping station by means of a small enclosure housing the low lift pumps, together with an office, hallway, toilet and locker room for the use of the men in the filter building and also for the use of the men in the present

pumping station. By this arrangement, it is possible to pass from any part of the pumping station to any part of the filter plant entirely within doors.

DESCRIPTION OF EQUIPMENT

The sizes and capacities of the various parts of the plant can perhaps best be described by starting at the present intake well and following the water through the plant.

Water is drawn from the present intake well through two suction pipes by the low lift pumps, discharging under a head of approximately 50 feet and delivering to either of two mechanical mixing tanks immediately under the entrance to the filter house. Each tank has a water capacity equivalent to 11 minutes of mixing time or twenty-two minutes total time at the rated capacity of the plant. The average mixing time will be about double these figures. Water will then pass from either or both these mixing tanks to either of two coagulating basins, providing a total coagulation period of three hours at the rated capacity of the plant. After coagulation, the water passes to the pipe gallery which adjoins the coagulating basin on its easterly side and thence passes to any or all of six mechanical filters each having a rated capacity of 2 million gallons per day or 12 million gallons total.

The mixing tanks, which are square in horizontal cross-section, form the cellar of the head house. The mechanical agitation equipment and the dry chemical feeders occupy the ground floor of the head house. Agitating equipment is water motor operated. Coagulant storage and the plant laboratory are located upon the second floor of the head house. Chemical is brought in by truck, lifted to the storage space by elevator and thence feeds by gravity.

The filters are arranged in one row with the pipe gallery intervening between the filters and the coagulation basins, thus avoiding any possibility of leakage entering the clear water reservoir. Filters, coagulating basins and clear well, together form a rectangle which can be enlarged in the future by extending each unit southward.

Filters are equipped with the usual hydraulic valves, perforated cast iron pipe laterals, cast iron wash troughs and the customary appurtenances of a modern filter.

Filtered water is discharged directly from each filter into a conduit suspended from the filter floors, in order to assemble all of the water at one place for chlorination as it drops into the clear water reservoir.

Water for washing the filters is supplied from a 100,000 gallon steel tank 28 feet in diameter and 23 feet high set on the top of an old foundation formerly occupied by a standpipe on the southerly part of the water works lot. This ground is sufficiently elevated to provide the necessary head for filter washing. The tank is enclosed by an attractive masonry structure also accommodated on the old standpipe foundation.

Provision is made for the aeration of the water by a fountain located on top of the coagulating basin and immediately in front of the filter house. Pipes and valves are so arranged that under ordinary circumstances, the aerators will not be used.

The drive-way and entrance to the plant come in from the high ground lying shoreward directly over the top of the coagulating basins. The tops of these basins, which are sodded over, form the "front yard" of the filtration plant, so to speak. The elevation of this construction and the filter house very largely hides the old pump house which occupies low ground immediately to the north. The main entrance to the combined pumping and filter plant will be through the filter house.

This plant is being engineered in coöperation with the Jerry Donohue Engineerng Company of Sheboygan.

With the completion of this plant, another will be added to the growing number of cities that find it worth while to treat the water of Lake Michigan, thus getting a clean water all the time, and obviating excessive chlorination.

SPECIAL FEATURES OF THE BUFFALO DISTRIBUTION SYSTEM[1]

By Wm. H. Grotz[2]

With the acquisition by purchase in 1868 of the plant and properties of the Buffalo City Water Works Company, the history of the local water works and distribution system began.

The plant and properties so acquired included a distribution system consisting of 33.9 miles of cast iron pipe ranging in size from 3 to 24 inches and was subsequently extended and improved so as to supply all sections of the city.

At first, additions made to this system were such as to take care of immediate needs and consisted principally of pipes somewhat small in size with insufficient attention given to the possible future growth of the city. Subsequently, however, as the city developed both industrially and in number of inhabitants, a more definite program seems to have been developed so that today the distribution system consists essentially of 736.8 miles of cast iron pipe ranging in size from 1½ to 60 inches with a complement of 7,159 hydrants and 16,306 valves.

From the time of the acquisition of the plant and equipment of the Buffalo Water Works Company and up to the year 1891, water was supplied to all sections of the city by one central pumping plant and at one pressure. In that year, however, due to the fact that the growth of the city extended to higher land in a northeasterly direction, it became necessary in order to supply this region with adequate water service to pump at a higher pressure for this section, thus necessitating a separation of service and the consequent division of this distribution service is known as the high and low pressure services. The high service, averaging 47 pounds, functions for the benefit of the higher elevation in the northeast section, while the low service, averaging 36 pounds, takes care of the southerly portion.

[1] Presented before the New York Section meeting, April 24, 1930.

[2] Assistant Engineer, Division of Water, Buffalo, N. Y.

The high service area has gradually grown in extent and service limits have consequently changed with the result that since 1921 only the southeastern section is supplied at the lower pressure. The two services are separated by closed valves, but connections between the high and low services have been provided ample to supply the entire low service area from the high pressure, or if need be to supply the lower portions of the high service from the low. Such extensions of the high service system as have been made were so made with the object of improving the pressures and providing more adequate fire protection.

A standpipe serving as a relief to the high service is located in the northeastern part of the city about 5 miles from the pumping stations. It is 40 feet in diameter and 85 feet high, of riveted steel plates erected on a masonary foundation and enclosed in an ornamental octagonal tower of cut stone and brick. A 36-inch pipe entering through the bottom serves as inlet and outlet. The elevation of base is 677, or 120 feet above mean lake level. The capacity, one foot below the top, is 790,000 gallons. Pumping is so regulated as to maintain a depth of from 50 to 55 feet, and depth is reported to the pumping stations half-hourly.

The low service is connected to a reservoir, which has a capacity of 116,200,000 gallons and is located 2 miles west of the pumping stations. It is divided into two bays and is partly in excavation with earth embankments 15 to 30 feet high. Elevation of water at full is 685.23 or 113 feet above mean lake level. The two bays are connected by a 36-inch gated pipe and each bay is connected by a 36-inch gated pipe to the low service distribution system. Insides slopes and bottom are lined with split stone laid in cement on concrete or clay puddle, the outside slope being sodded. The reservoir acts as an equalizer and distributor, and water is maintained at nearly full stage. Water levels are reported to both pumping stations hourly. It holds in storage two days maximum supply to the low service.

Water is supplied to the distribution system from two pumping stations, the Colonel Ward Station, located at the foot of Porter Avenue, and the Massachusetts Avenue Station, located at the foot of Massachusetts Avenue, about $\frac{3}{4}$ miles apart, on the city's western border.

At the Porter Avenue Station, the pumps are connected through hydraulically operated valves with each of two 60-inch discharge

mains supplying the high and low services. These 60-inch mains extend from the station about 2000 feet to connections with the distribution system, dropping down 64 feet through tunnels under the Erie Canal. A break in either would cut off the entire supply from the station to the service affected. To provide against this contingency, five valves on the low service discharge main and its connections with the distribution system are equipped for electrical operation with control of each located near the valve, and remote control of all provided for at the Water Division Storehouse at Jersey Street and Lakeview Avenue. By this arrangement, complete mechanical control is provided for this main, and it can be transferred to the High Service with reasonable celerity. In this event, remote control apparatus also provides for bleeding from the high to supply the low service mains.

At the Massachusetts Avenue Station, three 48- and one 36-inch discharge mains, each connect with at least two large mains in the distribution system. The cross connection gates here are provided for electrical operation with remote control in adjacent gate-keeper's house.

Serious consideration has been given to the plan of placing the entire system on one service, but there are many obstacles which must first be overcome. One of the main reasons, and very obvious, is the fact that a great portion of the older city with its old pipe and fixtures lies at a lower elevation and would naturally be adversely affected by an increase in pressure. Another of the chief obstacles encountered is the great loss in pressure between the pumping stations and the Kensington tower stand pipe which amounts under normal conditions to about 20 pounds due to friction losses in the pipe. Over half this loss occurs in the 60-inch discharge main from the Colonel Ware Pumping Station. To remedy this condition it will be necessary to construct a duplicate 60-inch discharge main so connected with the pumps at the pumping station as to be interchangeable with the high or low service and the header so equipped with proper gate valves that in the event of a break in the line only one pump would be out of commission. It is estimated that this main with its appurtenances will cost approximately $400,000.00. At some future time the difficulties now faced may be surmounted and the entire city placed on a single pressure system.

With the rapid development of the territory in the northeastern part of the city it became necessary to provide an additional increased

pressure for this the highest land in the city as the elevation there was too high to be taken care of by the regular high service. To accomplish this, the section was isolated by closing the valves on the border and the insertion of check valves in two regular 16-inch high service mains ordinarily supplying this territory. A combined booster pumping station and elevated water tank was erected within the area. This was supplied by a separate 16-inch main from the high service.

This pumping station consists of an elevated tank, within a tower, of 250,000 gallon capacity which was erected on a site 110 feet above lake level and rises to a height of 114 feet. The tower is of concrete, circular in shape. The structure consists of two concentric walls of reinforced concrete, the inner wall, 12 inches in thickness, supports the tank, the outer wall, 8 inches in thickness, forms an ornamental protecting shell for the whole apparatus.

The pumping plant consists of two 50 horsepower induction type motors equipped with automatic starters and manual control, attached to centrifugal water pumps, each capable of pumping 1200 gallons per minute. These pumps are so arranged as to work in unison or singly.

The suction and discharge lines are both 16 inches in diameter and the discharge line is provided with a 12 by 5 Venturi meter. The water elevation in the tank is controlled by automatic electrical devices. By virtue of this improvement the pressure in the surrounding territory has been raised to an average of 45 pounds. In the event of any failure of this plant to function the check valves in the high service will automatically open and supply water at a much reduced pressure.

The section supplied by this booster station is known as the auxiliary high service and has an average consumption of 750,000 gallons per day with a maximum demand of close to 3,000,000 gallons per day.

FLEXIBLE JOINT PIPE FOR RIVER CROSSINGS

One of the interesting features of the distribution system is the successful use of flexible joint cast iron pipes for under river crossings in navigable streams. There are three of these, all of 16-inch diameter pipes. The first was laid across the City Ship Canal at Harbor Turnpike in 1918 and was 240 feet long. The other two were laid across the City Ship Canal and Buffalo River at South Michigan

Avenue and are respectively 250 and 404 feet long from shore connection to shore connection.

The manner of assembling and installing these mains was somewhat novel and it might be well to explain the methods used. The pipes were class "B" with the Metropolitan type ball and socket joint, in which the lead remains in the bell when the joint is deflected. A trench across the river bottom was excavated by dredge to a depth of 37 feet below mean low water level between harbor lines, with the shore ends rising on an easy curved slope. The pipes were put together in sections on a flat scow, and as each joint was poured and caulked, it was deflected and another pipe added. Those sections which were to lie in the bottom of the river were made up of pipes 12 feet long, while those to be used at the shore ends were 6 foot lengths, this to provide greater curvature. The last pipe at each end was fitted at the top end with a standard bell for connection with land pipes.

Flat scows were lashed end to end the entire width of the river and the pipes transferred to these by a derrick scow. The entire length was thus made up and suspended to the sides of the scows by rope lashings. Rope lines were then attached to alternate pipes and fastened about snubbing posts, and when ready to lower, these lines were slacked off slowly about the snubbing posts, permitting the pipe to settle slowly to the bottom, the center portion of the main being allowed to settle first. When the main rested on the bottom, the ends above water were capped and an air test of 120 pounds applied. A diver followed up the joints during the test, caulking any joint found to be leaking. The shore ends were then connected in the usual manner, and a five foot fill of good earth was then deposited over the pipe trench in the river bed for protection. These lines are in service constantly and have given no trouble since laid, and are about the tightest mains in the system.

CLEANING OF MAINS

Another feature of the distribution system is the fact that over 166 miles of water mains in the city were cleaned during the years 1920–24 and continued cleaning of mains is underway at the present time. All water mains from 10 to 24 inches in diameter and over 30 years old, and over 8000 feet of 36-inch mains have thus far been cleaned. Approximately 10 percent of the 6-inch mains in the system have also been cleaned. The cleaning of water mains has delayed exten-

sive new large main extensions in some districts especially in the remote sections by increasing the volume and pressure throughout the territory affected.

PITOMETER SURVEY

A pitometer survey of the entire distribution system was begun in 1917 with a view to reducing the enormous consumption. At that time the daily average consumption was 168,000,000 gallons or 339 gallons per capita. As a result of this survey, and the work done by the Pitometer Department, subsequently organized within the Division of Water to continue the work, the daily average consumption has been reduced to 120,000,000 gallons or 209 gallons per capita.

This considerable reduction in consumption made possible the curtailment of the construction of large feed mains throughout the system resulting in a great saving, only those mains of urgent import having been added to the system.

In conclusion, I might say that the distribution system is a well coördinated integral unit with ample cross connections, excepting in a few outlying sections, so knitted together as to form a comprehensive and well functioning gridiron. Of course, there are well needed and desirable improvements to be made, such as a 30- or 36-inch belt line along the eastern border of the city extending from Broadway and Curtiss Street to Bailey Avenue and through Bailey Avenue to Warwick Avenue, there connecting with the Kensington standpipe. A 30- or 36-inch belt line is also necessary along the northerly boundary extending from Military Road to Main Street and thence to Kensington Tower, forming a complete primary feeder belt for the outlying sections. A proper and complete survey of the trunk mains in the system should be initiated and carried out at once, as this will most likely result in a considerable saving to the city.

ARBITRATING DISPUTES

The owners of one of the two leading motion picture theatres in a southern city recently discovered that they were losing a great many of their patrons because of the fact that their competitors were able to offer the patrons a much more comfortable temperature. They consulted their engineers and finally entered into a contract with a firm whose specialty was the installation of hydro-cooling systems, one of the stipulations of the contract being that the temperature of the theatre would be reduced from 8 to 10° as a result of the installation.

After the system had been completed, however, tests disclosed that no reduction in temperature had been effected and the owners refused to meet the contractors' demands for payment. The parties to the contract kept cool, even if the patrons of the theatre did not, and agreed that instead of the delay and expense of a lawsuit in order to settle their controversy, they would submit it to arbitration. Accordingly, the dispute was submitted to the American Arbitration Association, and arbitrated under its rules. Each party selected an arbitrator and mutually agreed upon a third chosen from the Association's National Panel of Arbitrators—in this particular case a man familiar with the problems of ventilating engineering and thoroughly qualified to pass upon the questions involved.

A time for the hearing was quickly arranged at the convenience of both parties, and after hearing the evidence of each side and examining the exhibits submitted, the arbitrators agreed that the conditions of contract had not been met and made their award in favor of the owners of the theatre. The fee paid by each party, to cover the expenses incurred in the hearing—which is the only charge made by the Association—was $25, as the amount involved in the controversy was less than $10,000.

This is one of the many cases submitted to the American Arbitration Association which indicates the adaptability of disputes involving engineering or construction problems to settlement by arbitration

and the value of having the merits of such cases decided upon by men who have expert knowledge and experience to guide them.

The settlement by arbitration of controversies arising out of business transactions is peculiarly applicable to the construction of water works and similar enterprises. Frequently, because of the very nature of a general contractor's obligations under a construction contract, differences of opinion with the owner or the engineer as to the quality of materials used, character of workmanship performed or financial adjustments as the work progresses arise, and since a stoppage of work, even temporarily, pending the uncertain and generally long-delayed results of litigation, is unthinkable in an industry where the element of time is so important and where each task is synchronized with the whole job to assure its steady and progressive completion, serious losses would result and economic disaster would be faced if litigation were the only form of relief available for the adjustment of these differences.

Many branches of the construction industry, conscious of the serious effect of protracted and costly delays in the adjustment of differences arising in connection with the performance of contractual obligations, have long ago found a remedy. Both contractor and owner have found it desirable to give the engineer decisive control over claims relating to the execution and progress of the work or interpretation of the contract documents. Stoppage of work is prohibited while the claim is pending and it is frequently agreed that the decision of the engineer shall be final.

Where a controversy involves matters over which the engineer has no control or where it is specifically agreed that his decision shall not be considered final, the parties to a contract have in recent years usually agreed to refer the controversy to arbitration. If there is a clause in a contract providing for arbitration in such a case, time and money are saved and the whole job moves faster.

Many contractors' organizations, engineering societies and material dealers' organizations are now actively urging the use of arbitration among their members and are coöperating with the American Arbitration Association in the establishment of arbitral tribunals where all inter-trade disputes may be heard and determined. Some of these tribunals have been set up within the organization itself and operate under rules prepared by the Association, while other bodies use the facilities of the Arbitration Association to dispose of the differences of their members.

Among the associations which have associated themselves with the American Arbitration Association are the American Association of Engineers, American Specification Institute, Associated General Contractors, Building Trades Employers' Association, New York Building Congress and many other engineering and construction bodies. Organizations which have endorsed the work of the American Arbitration Association or are participating in its educational work include the American Construction Council, American Institute of Consulting Engineers, American Institute of Electrical Engineers, American Society of Mechanical Engineers, Compressed Air Society, National Association of Master Plumbers, National Automatic Sprinkler Association and the Water Works Manufacturers Association.

Since the Joint Conference on Standard Construction Contracts called in 1921 by President Hoover, then Secretary of Commerce, and at which the American Water Works Association was represented, engineering and construction corporations have been increasingly aware of the importance of including in their contracts definite provision for the settlement of disputes by arbitration, and a part of the educational work of the trade organizations cöoperating with the American Arbitration Association has been the distribution of literature and information concerning legally correct arbitration clauses and informing members and affiliated bodies with the principle of commercial arbitration. More than 60,000 copies of the standard arbitration clause of the American Arbitration Association have been distributed by these cooperating bodies; and to those associations which do not have their own arbitration tribunals, the facilities of the Arbitration Association have been made available. These facilities include the Association's National Panel of Arbitrators, with a membership of approximately 7,000 outstanding business and professional men, all of whom generally serve without compensation and who are distributed over 1,700 of the most important cities of the country. Some of the members of this National Panel who are well-known in the engineering and public utility fields are Wm. D. Baldwin, Ralph H. Dick, Edward H. Emerson, Charles Hardy, J. S. Langthorn, H. C. Meyer, Jr., Charles R. Stevenson, Walter H. Travener and Pope Yeatman, of New York; Ezra B. Whitman, of Baltimore; Harley L. Clarke and W. E. Eberhart, Jr., of Chicago; F. J. Ryan, of Philadelphia; George S. Davison, Morris Knowles, A. Lyle Linderman and A. W. Robertson, of Pittsburgh. Firm believers

in the principle of commercial arbitration, these men stand ready to serve as arbitrators in disputes arising in their communities at any time.

What President Hoover thinks of commercial arbitration is indicated by the message sent by him to the American Arbitration Association on the occasion of the opening of the Association's new headquarters at 521 Fifth Avenue, New York City, last year. President Hoover said, "Arbitration of commercial disputes in place of avoidable litigation increases business efficiency by promoting good will and mutual confidence. Expeditious, regular settlement of business controversies within industry itself, by its own experts, is fundamental, but machinery is needed to make it effective. The American Arbitration Association provides a practical mechanism through which the method can be applied."

THE EFFECT OF IRON ON THE ACCURACY OF THE DETERMINATION OF DISSOLVED OXYGEN BY THE WINKLER METHOD

By O. M. Urbain[1] and J. N. Miller[1]

The methods for the determination of dissolved oxygen adopted as standard by the American Public Health Association are the Winkler method for unpolluted waters and the Rideal-Stewart modification of the Winkler method for waters containing organic matter. Neither of these methods makes any provision for the presence of iron (-ic or -ous) which liberates iodine in either case and for this reason simulates dissolved oxygen. The development of a method for the determination of dissolved oxygen which would give accurate results in the event that iron were present would be a very desirable addition to the literature of water and sanitary chemistry. In this paper we have given a set of corrections to be applied for the various concentrations of iron to the results obtained by the above methods.

It is a common belief that there is no further change after the final addition of the sulfuric acid preliminary to the titration step in the Winkler methods, and that the rest of the test may be carried through within a few hours as convenient. As a matter of fact, serious errors are the result of allowing this time to elapse previous to the titration if much iron is present. The magnitude of these errors varies with the concentration of the iron present and the time interval between the final addition of a sulfuric acid and the titration of the liberated iodine. In field work it is often necessary to wait as long as the following day to make the titrations. Even in the presence of small concentrations of iron this last procedure results in considerable error. The water in many streams in industrial sections contains an average of 100 p.p.m. of iron as the result of receiving pickling liquors, mine drainage, etc. In fact it is not uncommon to find such streams containing as high as 250 p.p.m. of iron. Some well waters also run quite high in iron. The results for dissolved oxygen obtained by the standard procedure in the presence of these high concentrations of

[1] Urbain Laboratories, Columbus, Ohio.

iron are unreliable even though the titrations are made within a short time after the final addition of acid. It is necessary, therefore, to make a correction for the blank due to the iron and the time interval between the final addition of the acid and the titration.

EXPERIMENTAL

In order to determine the magnitude of the errors and to provide a set of corrections to be applied to the dissolved oxygen figures for a given iron content of a water sample, and for a given length of time between the addition of sulfuric acid and the titration, a series of determinations was carried out in the laboratory in which these two factors were varied. The same water supply was used for the entire set of experiments. This consisted of a carboy of distilled water which had been aerated by bubbling air through it for about ten hours and then permitted to stand unstoppered for two weeks previous to its use. The dissolved oxygen content was thus permitted to come to equilibrium at the average temperature of the laboratory, which insured less change during handling in the experiments.

The bottles in which the determinations were carried out were carefully selected glass stoppered tincture bottles all having a capacity of between 276 and 280 cc. with the stoppers inserted. The procedure followed was to place in the bottle 1.00 cc. of a standard iron solution of such strength that it would impart the desired iron content to the contents of the bottle when it was filled with the aerated water. That is, if a determination was to be carried out in the presence of 100 p.p.m. of iron, 1.00 cc. of a solution of ferric ammonium sulfate containing 27.8 mgm. (average volume of bottles = 278 cc.) of iron per cubic centimeter was placed in the bottom of the bottle and the sample water then added. This procedure made it impossible to cause the bottles to overflow before inserting the stoppers, as is the recognized procedure, but a series of blanks showed that whatever variation resulted from this was a constant one. The bottles were filled with the water by means of a glass siphon tube. This tube was first inserted to the bottom of the bottle and then as the water level rose it was gradually withdrawn so that its tip remained several millimeters below the surface of the water. The bottles were filled to such a point that there was no air entrapped when the stoppers were inserted and at the same time there was very little if any loss of liquid. The contents of the bottles were thor-

oughly mixed, following the insertion of the stoppers, by inverting them a number of times.

The determinations were all made by the unmodified Winkler method.[2] They were carried up to the addition of the sulfuric acid as rapidly as possible. Following the addition of the acid and thorough mixing, definite lengths of time were allowed to elapse for the different sampies before the titrations were made.

In table 1 are given the results of the experiments. In column I are given the blanks containing no iron, but otherwise having had identical treatment with the other determinations. These blanks were titrated immediately following the addition of the acid. In column II are the concentrations in parts per million of iron present

TABLE 1

(I)	(II)	(III)									(IV)
		TITRATIONS AT STATED INTERVALS									
IMMEDIATE BLANK	Fe	5 minutes	10 minutes	20 minutes	30 minutes	1 hour	2 hours	5 hours	12 hours	24 hours	24-HOUR BLANK
	p.p.m.										
8.53	100	8.70	8.95	9.22	9.40	9.83	10.45	11.45	13.35	13.50	8.58
8.55	50	8.58	8.66	8.78	8.93	8.98	9.30	9.93	10.97	11.12	8.57
8.54	25	8.59	8.59	8.60	8.67	8.82	8.89	9.21	9.70	9.87	8.56
8.53	10	8.55	8.64	8.56	8.60	8.60	8.74	8.80	9.14	9.27	8.57
8.50	1	8.50	8.50	8.54	8.55	8.67	8.69	8.68	8.72	8.75	8.53

in each set of samples. Column III contains the results of the titrations made after the time intervals indicated at the top. In column IV there is a second set of blanks, made up exactly the same as those in column I, but titrated after standing twenty-four hours.

The results clearly indicate that for waters containing more than 50 p.p.m. of iron the methods concerned are wholly unreliable, and for waters containing less than 50 p.p.m. of iron, serious errors result if the titration step does not immediately follow the preceding parts of the determination. That the iron does not react quantitatively to liberate its equivalent of iodine is due to the fact that there is not a sufficient amount of potassium iodide present to force the reaction in

[2] Standard Methods for the Examination of Water and Sewage, American Public Health Association. Also, L. W. Winkler, Berichte, 21, 2843, 1888.

this direction. In the iodimetric scheme for the determination of iron developed by C. Mohr,[3] which is based on the reaction:

$$2FeCl_3 + 2HI = 2HCl + 2FeCl_2 + I_2$$

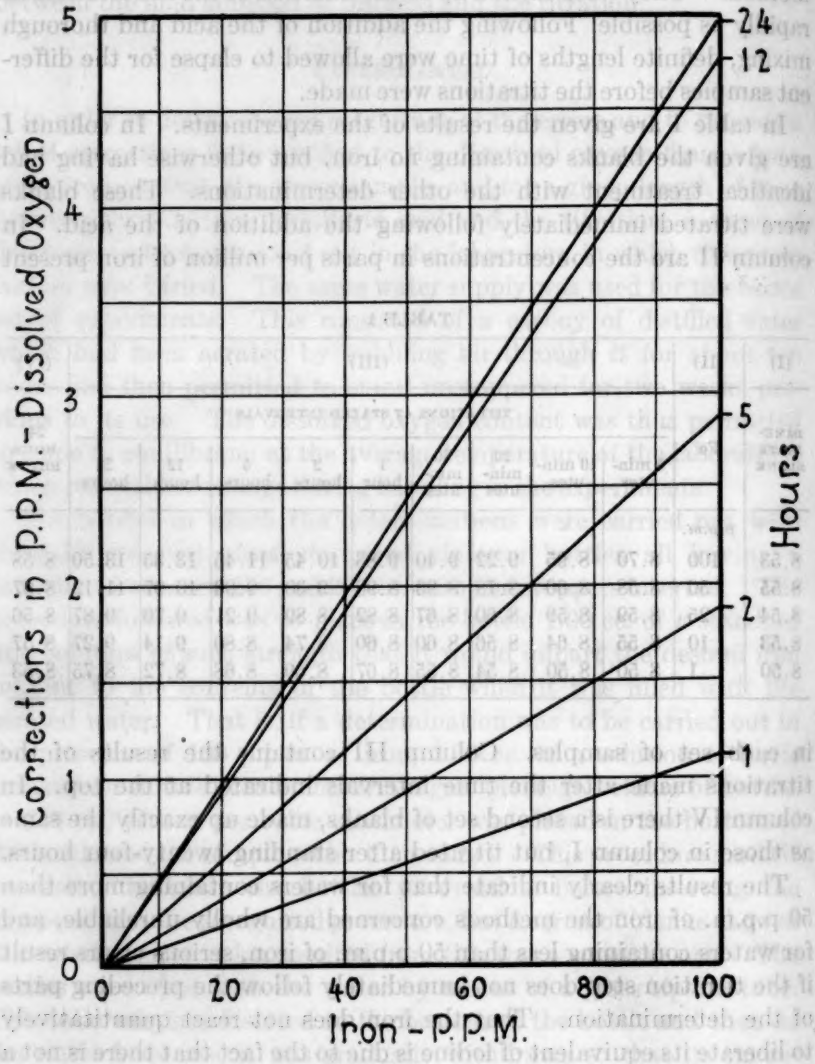

FIG. 1

it is found that there is a tendency for this reaction to go in the reverse direction, if an excess of hydriodic acid is not present. The

[3] Carl Mohr, Ann. d. Chem. u. Pharm., 105, 53.

fact that the concentration of potassium iodide called for in the Winkler method is relatively low accounts for the fact that the liberation of the iodine in the experiments took place rather slowly.

In order to make the experimental results as contained in table 1 available as corrections to apply to dissolved oxygen determinations made in the presence of known amounts of iron, figure 1 is presented There are five curves each indicating the correction to be applied when the indicated period of time has elapsed between the final addition of sulfuric acid and the titration. The corrections are to be subtracted from the values obtained for dissolved oxygen, either by the original or modified Winkler method.

NOTE ON THE SOLUBILITIES OF SUCCINCHLORIMIDE[1]

By Cyrus B. Wood[2]

An excess of succinchlorimide that had been recrystallized from glacial acetic acid (m.p. 146–7°C. (softens 143) uncorrected) was stirred with each solvent listed (table 1) for thirty minutes, cooling to maintain a temperature of 20°C. The mixture was filtered quickly and a measured volume titrated with 0.1 N sodium thiosulfate.

The glycerine solution does not evaporate spontaneously at room temperatures, while *n*-amyl alcohol alone, of the remaining solvents

TABLE 1

SOLVENT	APPROXIMATE SOLUBILITY
	percent
Carbon tetrachloride	0.09
Eucalyptol	0.16
n-amyl alcohol	0.22
Glycerol	0.33
Xylol	0.76
Ethanol (95 percent)	0.98
Toluene	1.10
Water	1.25
Benzene	1.70
Methanol	1.73
Chloroform	3.77
Glacial acetic acid	4.81
Ethylene chloride (symmetrical dichloroethane)	5.41
Acetylene tetrachloride (symmetrical tetrachloroethane)	6.63
Acetone	9.71

listed, gives a crystalline residue that yields no test for positive chlorine, on evaporation under a fan at 25 to 30°C. The other solvents listed give crystals that melt above 140°C. only in the cases of carbon tetrachloride, xylol, water, benzene and chloroform, and the melting point can be called sharp only in the case of benzene.

[1] Journal, October, 1928, page 535.

[2] Takoma Park, Dist. of Columbia.

Succinchlorimide is insoluble in liquid petrolatum, and is slightly or moderately soluble in concentrated sulfuric, nitric, hydrochloric, formic and lactic acids, in syrupy phosphoric acid, and in acetic anhydride, ethyl ether and ethyl acetoacetate. Except for liquid petrolatum,—which is not a solvent—the solvents just named cannot, it is believed, be considered as inert.

Allen Hazen

Died July 26, 1930

This Association lost one of its most able, forceful and prominent members through the death, from heart disease, at Miles City, Mont., on July 26, of Allen Hazen who was then taking a combined pleasure and business trip in the West.

Born in Vermont in 1869, Mr. Hazen was graduated at an early age from the New Hampshire College of Agriculture and Mechanic Arts. In 1888, after completing a special course in sanitary chemistry at the Massachusetts Institute of Technology, he was appointed upon the recommendation of Dr. T. M. Drown, then chief chemist of the Massachusetts State Board of Health, to take charge of the Board's experiment station at Lawrence.

While Mr. Hazen was at Lawrence, the germ theory of disease was very slowly becoming recognized by sanitarians. The work at the experiment station, which was greatly stimulated by problems arising from typhoid epidemics at Lowell and Lawrence, the Asiatic cholera epidemic at Hamburg, Germany, and dangers incurred through the appearance of Asiatic cholera on ships in New York Harbor, related largely to methods of purification of water and sewage. The Lawrence investigations were a classic pioneering work into methods of purification from a combined engineering, chemical and biological viewpoint, and did much to direct attention to and confirm the germ theory of disease. Mr. Hazen also made extensive studies of the hydraulics of filters, and of the grading of filter sands.

Many of the results of the experimental work at the Lawrence Experiment Station were availed of by the late Hiram F. Mills, Engineer member of the Massachusetts State Board of Health, in his design and supervision of construction of the intermittent sand filter for the city water supply of Lawrence, drawn from the polluted Merrimack River. In this filter work Mr. Mills was assisted by Mr. Hazen.

Mr. Hazen's next work was at the World's Fair in Chicago, in 1893, where he was in charge of the disposal of sewage at the fair grounds; following which he spent a year in travel and study in Europe.

Soon afterward Mr. Hazen entered private engineering practice in Boston with Mr. Albert F. Noyes, under the firm name of Noyes & Hazen. After Mr. Noyes' death in 1896, Mr. Hazen came to New York City, and became engaged in 1897 in the design and construction of the water filter plant at Albany, the first modern continuously operating slow sand filter plant in the United States.

In 1904 Mr. Hazen formed a partnership with Mr. George C. Whipple, which continued until Mr. Whipple's death in 1924. In later years there were associated with him in this engineering practice Messrs. Weston E. Fuller, Malcolm Pirnie, Chester M. Everett and L. N. Babbitt.

While water purification in early years was a major item in the practice of the Hazen firm, their activities related to all branches of engineering in the fields of water supply and water distribution, especially dams and large pipe lines, as well as valuation work for rate making and municipal acquisition. He served a large number of the prominent water departments and water companies in various parts of North America.

Mr. Hazen was particularly interested in hydraulics and in hydrography, and in addition to writing many papers on sanitary subjects made a number of valuable and practical contributions to engineering literature on the subject of run-off of streams. He also wrote several books on subjects of interest to water works engineers and officials, including "Filtration of Public Water Supplies," "Clean Water and How to Get It," "Meter Rates for Water Works" and his recently published book "Flood Flows." In collaboration with Mr. Gardner S. Williams, he compiled a volume of Hydraulic Tables, a book which is in extensive use. He was also editor of Section 14, the water supply section of the American Civil Engineer's Pocket Book.

Mr. Hazen was a thorough student who acquainted himself personally with the various details of all his problems. He applied to them an unusually clear insight, and thus drew conclusions quickly and with precision. He had a remarkable aptitude for clear and concise statement both in speech and in writing, to which he added exceptional skill in putting the results of his investigations into simple and practical forms so that others could readily make use of them.

The influence of Allen Hazen's leadership in advancing water works

practice during his engineering day and age was unquestionably great. That leadership was due largely to his unusual capacity for clear straight thinking on all major elements of an engineering proposition, but it was also related in part to the characteristics inherited from his New England ancestry. In weighing the latter it is well to consider his own statement that the vocation of 85 percent of his male forebears for several generations was that either of a Congregational clergyman or of a missionary.

Mr. Hazen became a member of the American Water Works Association in 1896 and was elected an Honorary Member in June, 1930. He received the honorary degrees of Doctor of Science from New Hampshire College in 1913 and Dartmouth College in 1917.

In 1902 he was married to Miss Elizabeth McConway, daughter of William McConway, one of the leading citizens of Pittsburgh, Pa. He is survived by Mrs. Hazen, four daughters and two sons, the older one now a student at Dartmouth College.

GEORGE W. FULLER.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, **12**: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

The Composition of Water and Mosquito Breeding. WILLEM RUDOLFS and JAMES B. LACKEY. Am. J. Hyg., **9**: 160–80, 1929. From Chem. Abst., **23**: 1974, April 20, 1929. Data are furnished correlating composition of water and its biological content with the abundance of mosquito breeding. Larvae are killed within 24 hours when pH of natural water is changed rapidly; while gradual change in reaction fails appreciably to affect death rate. Possible that under certain conditions waters with low pH values are more favorable to mosquito breeding than those with medium or high pH values, and vice versa. Relation between microscopic content and mosquito breeding is stressed. Tables and graphs illustrating salient facts presented are given, and bibliography is appended.—*R. E. Thompson.*

The Determination of Dissolved Oxygen with the Micro-Winkler Apparatus of Thompson and Miller. A. W. SNOKE. Ecology, **10**: 163–4, 1929; cf. C. A., **22**: 3319. From Chem. Abst., **23**: 1973, April 20, 1929. Apparatus has been found useful not only for determination of dissolved oxygen where small samples (10 cc.) were necessary, but also in many cases where original macrochemical method would normally be used. Data on 3 samples show as great accuracy for microchemical as for macrochemical method, and former's convenience and accuracy recommend it for field work.—*R. E. Thompson.*

Purification of (Sugar House) Waste Waters. G. A. PARK ROSS and L. FOUQUEREAUX DE FROBERVILLE. Suppl. circ. hebd. com. centr. fabr. sucre France No. 2044, May 27, 1928; Chimie et industrie, **20**: 1067, 1928. From Chem. Abst., **23**: 1976, April 20, 1929. Recommended that all waste waters be combined and treated either by carbonation (make alkaline with milk of lime, heat to 50–5°, neutralize with carbon dioxide, precipitate calcium carbonate by heating to 90–5° and decant) or by chemical precipitation (treat with iron sulfate and lime, allow precipitate to settle and decant). Sludge from either process may be dried and used as fertilizer.—*R. E. Thompson.*

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[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

Experiments on the Purification of Beet-Sugar Wastes by Stream Flow Aeration. MAX LEVINE and A. H. NELSON. Sewage Works J., 1: 40–5, 1928. From Chem. Abst., 23: 1976, April 20, 1929. Waste was forced over series of cleats in thin stream into trough, thus increasing aëration. Storage tank was 80 percent emptied each hour. Results given.—*R. E. Thompson.*

Improvements in the Operation of a Textile Wastes Treatment Plant. STUART E. COBURN. Sewage Works J., 1: 77–9, 1928. From Chem. Abst., 23: 1976, April 20, 1929. Waste flows by gravity to 5 sedimentation tanks, to sludge drying beds, and to intermittent sand filters. Sulfuric acid is used to increase H-ion concentration to pH 6 before addition of alum. Clear, stable, and practically colorless effluent is obtained. Filters are cleaned but twice each year.—*R. E. Thompson.*

Disposal of Liquor Effluents from Gas Works. 2nd Report, Inst. Gas Eng., Liquor Effluents Research Comm. Gas. J., 182: 1016–8, 1928. From Chem. Abst., 23: 2018, April 20, 1929. In vertical retort plant at Hinckley, content of higher phenols was reduced by introduction of tar extractor in foul main. Carefully controlled disposal of effluent into sewage is considered satisfactory and can be further improved by separate disposal of devil liquor, by chimney spraying, etc.—*R. E. Thompson.*

Electrolytic Preparation of "Distilled" Water. OSWALD GCRTH. Chem.-Ztg., 53: 52–3, 1929. From Chem. Abst., 23: 2107, May 10, 1929. One or many cells, divided into 3 compartments by porous diaphragms, provided with anodes and cathodes in their outer compartments and fed with water in middle compartments, cause impurities to gather in outer compartments and purer water to be left in middle one. Continuous purification is possible. Plants have been built to produce 3 to 250 liters of purified water per hour. Current consumption is about 3–4 kilowatt hours per 100 liters.—*R. E. Thompson.*

Some Comparative Colorimetric Determinations. R. WASMUHT. Z. angew. Chem., 42: 133–4, 1929. From Chem. Abst., 23: 2119, May 10, 1929. Comparative studies with immersion colorimeter showed that manganese can be determined by lead peroxide-nitric acid oxidation to permanganate within 5 percent of actual manganese content. Results with persulfate oxidation were not as good, as shade developed was often quite different from that of pure permanganate.—*R. E. Thompson.*

A New Method for the Colorimetric Determination of Nitrates in Soils and in Waters. LUIGI UMBERTO DE NARDO. Compt. rend., 188: 563–5, 1929. From Chem. Abst., 23: 2123, May 10, 1929. Pyrogallolsulfonic acid is an excellent reagent for nitrate. Take 5 grams pyrogallol and heat for few minutes with 10 cc. concentrated sulfuric acid at 80 to 90°. Cool and add water to make 200 cc. Small quantity of sodium acid sulfite may be added as preservative. Reagent is very sensitive. As little as 0.0005 mgm. gives pink color. With larger quantities a reddish brown or olive-green shade is obtained. Color is compared with standards. If test is too strong, use pyrogallol as reagent instead of the sulfonic acid.—*R. E. Thompson.*

The Precipitation of Calcium and Magnesium from Sea Water by Sodium Hydroxide. ELEANOR M. KAPP. Biol. Bull. Marine Biol. Lab., 55: 453–8, 1928. From Chem. Abst., 23: 2194, May 10, 1929. Charts given showing effects of adding varying concentrations of sodium hydroxide to sea water and experimental mixtures. Magnesium is rapidly precipitated at about pH 10.2. Small quantity of calcium is precipitated throughout.—*R. E. Thompson.*

The Use and Behaviour of Protective Coating on Underground Pipes. GORDON N. SCOTT. Oil & Gas J., 27: 29, 127–8, 195, 1928; Am. Petroleum Inst. Bull., 10: 2, 78–93, 1929. From Chem. Abst., 23: 2226. May 10, 1929. Discussion of few of important aspects of care in application of protective coatings, types of failures which have been found to occur in service, and manner in which false conclusions may be drawn from tests on specimens buried in selected soils. One objection to mill-coated pipe is ease of rupture of coating by rough handling. Continuity of coating is essential, so as to prevent localized corrosion; hence patch work, unless done very carefully, should be avoided. Air entrapped in coating will cause rupture of fabric. Added life that may be realized from application of particular coating is function of conditions of service to which coating will be subjected. Generally, destruction of protective coating in service may be either chemical or physical or a combination of these. Soil which expands or contracts with change of moisture content and which has ability to adhere to coating causes considerable damage to certain classes of protective coatings; this may be called "soil stress effect." Chemical changes may involve oxidation, and less of volatile constituents. Physical changes may be due to loss of bond between asphalt and metal, softening and flowing of coating, distortion of coating by movement of earth caused by uneven trench bottoms and settling of backfill. Temperature changes cause considerable distortion, cracking and checking of coating. Laboratory tests show that soils which give surface or sub-surface checking may be expected to have distorting effect upon coatings. Such soils are usually highly colloidal. No direct relation between soils which are corrosive to bare pipe and soils which are highly destructive to coatings was noted.—*R. E. Thompson.*

Determination of Organic Matter in Sea Waters. JOSÉ GIRAL PEREIRA. Inst. Españ. Oceanografia Notas y Resúmenes, II, No. 4, 25 pp. From Chem. Abst., 23: 2230, May 10, 1929. SCHULZE-TROMMSDORFF method (alkaline permanganate, acidulation, addition of oxalic acid and back titration) was used, although recognized as defective.—*R. E. Thompson.*

Embrittlement Prevention in Steam Boilers. FREDERICK G. STRAUB. Power Plant Eng., 33: 173–4, 1929. From Chem. Abst., 23: 2231, May 10, 1929. Boilers operated for 13 years at pressure of 160 pounds, in which ratio of sodium sulfate to total alkalinity, expressed as sodium carbonate, equal to 2 was maintained, show no embrittlement. Two plants in Champaign-Urbana district operated at 160 pounds pressure on untreated water have encountered embrittlement. In another community, well water free from sodium carbonate received water treatment introducing high sodium carbonate alkalinity,

sulfate content being low; a plant using this treated water encountered embrittlement while another using the raw water was free from trouble. Adoption of recommendations of American Society of Mechanical Engineers Boiler Code Committee in 1926 advising ratios of alkalinity to sodium sulfate at various steam pressures has done much toward elimination of trouble. Proper ratio should be maintained at all times, as embrittlement may act quickly. Half proper ratio is no better than none. Phosphate treatment, which maintains proper ratio between alkalinity and soluble phosphate content (not total phosphate), seems to be more desirable as lower ratio may be effective. Tannate and acetate are helpful in inhibiting embrittlement.—*R. E. Thompson.*

The Action of Active Chlorine on Aquatic Plants. K. GEMEINHARDT. Kl. Mitt. Ver. Wasserversorg. Abwässerbeseitig., 2: 124–30; Chem. Zentr., 1927, II, 1743. From Chem. Abst., 23: 2231, May 10, 1929. Introduction of strongly chlorinated waste water into streams causes damage to vegetation and microorganisms, if water contains more than 15 p.p.m. chlorine. For removing undesirable vegetation in water reservoirs, about 100 p.p.m. chlorine may be added to water during working pause and allowed to act as long as possible. Mechanical removal of dead vegetable matter should bring relief from nuisance for some time.—*R. E. Thompson.*

Electroösmotic Purification of Water. S. KOMAGATA. Researches Electro-Tech. Lab., Tokyo, Japan, No. 216: 20 pp., 1927. From Chem. Abst., 23: 30, May 10, 1929.—*R. E. Thompson.*

The Water of Several Hungarian City Supplies, Wells, and Spas Near Lake Balaton and That of Several Railroad Stations. I. SZANYI. Kisérl. Közl., 31: 1–20, 1928. From Chem. Abst., 23: 2231, May 10, 1929. Nearly 900 samples of drinking water were analyzed. Water of city supplies was found to be good; 52.8 percent of the examined railroad station wells and 37.5 percent of spas were found satisfactory. Consumption of water in cities with public supplies varies from 29.7 to 182.5 liters per person per day. Public supplies should be established, if possible, since ordinary wells yield good drinking water only if cleaned frequently.—*R. E. Thompson.*

Sewage from Dye Works, Its Effect on Streams, and the Possibility of Purifying It. A. PRITZKOW. Kl. Mitt. Ver. Wasserversorg. Abwässerbeseitig., 1: 149–54, 1925: Chem. Zentr., 1927, II, 1745. From Chem. Abst., 23: 2231, May 10, 1929. Dye waste waters may be decolorized by bleaching, chemical clarification, or filtration over brown-coal cinders.—*R. E. Thompson.*

Physical and Chemical Considerations of Streams into Which Sewage is Discharged. A. SCHULZE-FORSTER. Kl. Mitt. Ver. Wasserversorg. Abwässerbeseitig., 3: 249–63; Chem. Zentr., 1927, II, 2334. From Chem. Abst., 23: 2231, May 10, 1929. Methods of examining water to determine extent of deterioration by sewage discharges are discussed. Use of interferometer for detecting origin of pollution is dealt with. Acid-combining power, defined as amount of SO_3 in milligrams with which 1 liter of water can combine, is important.—*R. E. Thompson.*

Super-Cooled Water. LEONARD HAWKES. Nature, 123: 244, 1929. From Chem. Abst., 23: 2339, May 20, 1929. There appears to be a great change in properties of super-cooled water between −9° and −12°. At −9°, water is quite fluid, while at −12° water "froze," showing no sign of crystalline structure.—*R. E. Thompson.*

Dairy Waste Waters, Their Properties, and Their Purification. A. PRITZKOW. Kl. Mitt. Ver. Wasserversorg. Abwässerbeseitig., 1: 27–31, 1925; Chem. Zentr., 1927, II, 1745. From Chem. Abst., 23: 2232, May 10, 1929. Purification of dairy wastes may be limited to retention of fatty constituents and coarse particles, if conditions are favorable in stream into which waste is discharged. Otherwise, waste water should be used on sewage irrigation fields, or treated on trickling filters, or by biological methods.—*R. E. Thompson.*

The Determination of Alkali in Seepage Water (in Oil Wells). K. L. MALYAROV. J. Russ. Phys.-Chem. Soc., 60: 829–34, 1928. From Chem. Abst., 23: 2387, May 20, 1929. Treat 100 cc. of water with slight excess of barium chloride solution at 100°. Filter, evaporate filtrate in platinum dish to dryness together with 6–15 grams oxalic acid. Heat to dull redness, cool, dissolve in hot water, filter, and titrate with 0.1–0.5 N hydrochloric acid. Analysis is based on assumption that residue contains sodium carbonate.—*R. E. Thompson.*

The Confirmatory Test for Aluminum. RAYMOND GEMMILL, ROBERT BRACKETT and C. R. MCCROSKY. J. Am. Chem. Soc., 51: 1165, 1929. From Chem. Abst., 23: 2388, May 20, 1929. PAÑGANIBAN and SOLIVAN (C. A., 22: 3859) recently published modification of the THÉNARD blue test for aluminum, using asbestos fiber instead of filter paper. Similar tests were made by authors prior to this publication. Modified procedure also works well in zinc test.—*R. E. Thompson.*

The Temperature Distribution in the Acetylene Welding Flame. F. HENNING and C. TINGWALDT. Z. Ver. deut. Ing., 72: 1828–30, 1928; cf. C. A., 23: 1350. From Chem. Abst., 23: 2401, May 20, 1929. In addition to measuring spatial distribution of temperature, authors found that maximum temperature was lowered 40° by 20 percent oxygen and 60° by 7 percent excess acetylene.—*R. E. Thompson.*

Choice of Materials for Steam Turbine Blading. E. A. KRAFT. Elektrotechnik und Machinenbau, 46: 301–5, 1928. From Chem. Abst., 23: 2403, May 20, 1929. Five percent nickel steel and stainless steel are only materials which can be used in high-temperature, high-pressure stages of modern turbines. Up to about 200° their physical properties are about same, but above this temperature those of nickel steel deteriorate rapidly, while those of stainless steel slope off gradually to 500°. Attempts to minimize corrosion of steel blading by surface treatment were not satisfactory. At present, stainless steel is best material to use, although it is probably not the final answer to problem.—*R. E. Thompson.*

Metals for Blades of the Modern Steam Turbine. A. BODMER. Chaleur et ind., 9: 163–81, 239–44, 1928; cf. C. A., 22: 3385. From Chem. Abst., 23: 2403, May 20, 1929. Steel with 5 percent nickel is best metal at present. If steam is pure, turbine-vane corrosion can be avoided, but if salts, etc., are present, corrosion is certain. Erosion is more difficult to avoid than corrosion. The higher the steam temperature, other conditions being equal, the less is the corrosion. Various stainless steels have been tried; they become fragile and undergo oxidation in due course. Alloys with high nickel and chromium contents (A. T. V. metal) are best of all. Their resistance to oxidation and erosion is very good even with high-temperature steam.—*R. E. Thompson.*

Turbine Corrosion and Degasification. G. PARIS. Chaleur et ind., 9: 188–90, 1928. From Chem Abst., 23: 2411, May 20, 1929. Corrosion may occur (*a*) on blade or (*b*) on edge of blade, and may be rust or just erosion by water droplets. Corrosion may result from faulty working, or from material entrained in steam, such as oxygen, water, or solids. Means of reducing corrosion include making blades of difficultly oxidizable metal and degasification of the water.—*R. E. Thompson.*

Galvanized Pipes—Metal Coatings. BATTIGE. Apparateabu, 41: 53–5, 1929. From Chem. Abst., 23: 2411, May 20, 1929. Author claims that galvanizing gives no permanent protection against corrosion in water pipes.—*R. E. Thompson.*

New Ways for Sterilization. RUDOLF DEGKWITZ. Klin. Wochschr., 8: 342–8, 1929. From Chem. Abst., 23: 2457, May 20, 1929. Good historical discussion of concept of oligodynamic action. Original work deals largely with practical application of highly dispersed metallic silver preparation (solid, not colloidal) to water sterilization. Preparation will sterilize emulsions containing 100,000 colon bacilli per cubic centimeters in 10 minutes.—*R. E. Thompson.*

Contaminated Water as a Source of Surface Flavor in Pasteurized Creamery Butter. DONALD B. SHUTT. Sci. Agr., 9: 216–20, 1929. From Chem. Abst., 23: 2506, May 20, 1929. Surface flavor of butter was prevalent in rural creameries, especially after prolonged periods of wet weather. Five creameries were inspected. All produced butter of sewage-like, unclean, or putrefactive odor. Water supplies of all the creameries contained *Pseudomonas fluorescens* in large numbers. Sterile butter when inoculated with *P. fluorescens* at 25° for 28 days developed typical surface odor and flavor. Pasteurization of the water at 93° for 10 minutes renders it safe for use.—*R. E. Thompson.*

Rapid Titrimetric Determinations of Sulfate in Drinking and Service Waters with the Aid of Visual Conductivity Titration. H. FEHN, G. JANDER and O. PFUNDT. Z. angew. Chem., 42: 158–9, 1929. From Chem. Abst., 23: 2516, May 20, 1929. Boil 50 cc. water to deposit calcium carbonate. Cool in freezing mixture to room temperature and filter into conductivity glass. Add equal volume of alcohol and titrate quickly with standard barium acetate,

using mirror galvanometer instead of telepone for conductivity determination. Whole determination can be carried out in 10 minutes.—*R. E. Thompson.*

Sterilization of Water by Chlorine. F. DIENERT and P. ÉTRILLARD. Compt. rend., 188: 826–9, 1929; cf. C.A., 22; 610, 3008. From Chem. Abst., 23; 2517, May 20, 1928. Hypothesis is adhered to that sterilizing action of chlorine is derived from its ability to unite with organic protoplasm of bacteria and destroy them.—*R. E. Thompson.*

Water-Sampling Apparatus (Olszewski-Keyl). W. OLSZEWSKI. Chem.-Ztg., 53: 149, 1929. From Chem. Abst., 23: 2516, May 20, 1929. Modified SPITTA-IMHOFF sampler for water, to open automatically at specified depths, described briefly.—*R. E. Thompson.*

The Problem of Purifying Water by Coagulation. I. I. KRASIKOV and A. LITYAGO. Zapiski Belorusskoi Gosudarstv. Akad. Sel'skogo Khozyaistva, 4: 261–70, 1927. From Chem. Abst., 23: 2517, May 20, 1929. Potassium alum and ferric ammonium sulfate were used as coagulants. Potassium alum found to be the better coagulant; addition of 0.1 gram per liter did not increase the alumina content.—*R. E. Thompson.*

Comments on Methods for Determination of Residual Chlorine. LINN H. ENSLOW. Sewage Works J., 1: 30, 1928; cf. C. A., 23: 1972. From Chem. Abst., 23: 2517, May 20, 1929. The *o*-tolidin method seems to be most reliable as index of effective chlorination of sewage. Factors to be considered in making test dealt with.—*R. E. Thompson.*

Note in Regard to the Manganese Determination in Water. J. DE GRAAFF. Chem. Weekblad, 26: 103–4, 1929. From Chem. Abst., 23: 2518, May 20, 1929. Manganese adheres to sides of bottles and may cause discrepancy in analysis if not removed. It will most likely be found in water from which sediment of calcium carbonate has formed.—*R. E. Thompson.*

Note on Base-Exchange Water Softeners. C. O. CLARK. Soc. Dyers Colourists, 45: 36–9, 1929. From Chem. Abst., 23: 2518, May 20, 1929. Base-exchange systems (natural and synthetic) of softening water are compared with chemical systems, and data given on superiority of latter. Proper maintenance of base-exchange water softening plants is discussed and the advantages of water of zero hardness over hard water in textile, tanning, and paper industries are pointed out.—*R. E. Thompson.*

Natrolite Filter for Softening Water. STEN TYDÉN. Svensk Kem. Tid., 40: 250–6, 1928. From Chem. Abst., 23: 2518, May 20, 1929. Swedish water softening material, "Natrolite," is closely related to the American "Zeolite." Composition is as follows: silica 62.9, iron oxide 8.5, alumina 17.0, titanium oxide 1.0, calcium oxide 1.4, magnesia 1.3, potassium oxide 1.9, sodium oxide 2.7, water 3.3, and difference from 100 percent, 0.11. One cubic meter softens 112.4 (metric) tons of local water which contains 8.6 and 0.9 grams per 100 liters of lime and magnesia respectively.—*R. E. Thompson.*

Chemical and Physical Changes in a Cast-Iron Well Casing. G. THIEM. Gas u. Wasserfach., **71**: 1239–41, 1928. From Chem. Abst., **23**: 2519, May 20, 1929. Cast-iron well casing that had been in use about 30 years under water with average carbon dioxide content of 56.3 p.p.m. showed specific gravity of 2.97, compared to normal of 7.25. Iron content had decreased from about 93 to 52 percent and percentages of carbon, manganese, silicon, phosphorus and sulfur had increased. Casing retained its shape and would have been usable if left in place and not subjected to mechanical stress.—*R. E. Thompson.*

Treating Boiler Water. L. M. WILLIAMS. Refiner Natural Gasoline Mfr., **8**: 98, 100, 102, 1929. From Chem. Abst., **23**: 2519, May 20, 1929. Plant for treatment of water having high sulfate and chloride content and chemical control methods for such plant described.—*R. E. Thompson.*

The Work of the Emscher Association on the Recovery of Phenol from Ammonia Liquors of the Ruhr Mining Companies. H. WIEGMANN. Glückauf, **64**: 397–404, 435–41, 1928. From Chem. Abst., **23**: 2550, May 20, 1929. Ammonia liquor is washed with benzene, toluene, or other suitable extraction liquid, wash medium is separated, and solvent is recovered and re-used. Phenol-containing benzene may also be washed with soda lye and the alkali regenerated and re-used after caustification. Five plants are described, comprising, in general, a raw liquor vessel, filter, clear water container, heat exchanger, mixing pump, separating vessel, distillation apparatus, benzene reservoir, phenol reservoir, and coolers. As rule a plant will treat 120–150 cubic meters per day of liquor containing about 3 to 4.5 grams phenol per liter. Cost figures are analyzed. Benzene containing pyridine extracts phenol better than pure benzene. Direct and indirect recovery of wash fluid is discussed. Purest crude phenol oil obtained by benzene washing of ammonia liquor contains: phenol 85, benzene 6, pyridine 4, and tar 5 percent. Crude phenol oil was readily salable. Waste liquor after phenol extraction contains 0.7 to 0.8 gram per liter. About 25 percent benzene, on the waters, is required, and about 1.2 to 1.4 grams per liter remains in water and must be recovered. Seventy-five percent crude phenol now markets at 75 to 78 cents per kilogram.—*R. E. Thompson.*

Bitumen as a Protection Against Corrosion in the Chemical Industry. A. W. RICK. Chem. Fabrik., 1929, 100–1. From Chem. Abst., **23**: 2583, May 20, 1929. Specially prepared bituminous lacquers and thicker solutions of bitumen or bituminous compositions are far better than oil paints, tar paints, crude asphalts, and petroleum pitches as protectives against corrosion. These give necessary impenetrability, toughness, resistance to attacks by chemicals, etc.—*R. E. Thompson.*

Electric Welding in Gas Works and Water Works. J. SAUER. A E G Mitt., 1929, 305–7. From Chem. Abst., **23**: 2688, June 10, 1929.—*R. E. Thompson.*

The Economic Position of Dephenolating Plants. A. WEINDEL. Glückauf, **64**: 498–502, 1928. From Chem. Abst., **23**: 2550, May 20, 1929. Water

solubility of phenol homologs falls with increasing molecular weight; hence extraction with organic solvent will preferentially remove cresols and xylenols while the more soluble phenol will tend to remain and be lost, thereby defeating water pollution regulations and also diminishing revenue. In attempting to improve phenol recovery, distillation process of removing benzene is ruled out because of excessive steam charges. Better recovery can be obtained with alkali treatment. All that is required is to treat liquors with alkali more often and to regenerate alkali in between. Cost of additional pumping, etc., is negligible compared with added steam costs. Such improvements will enable plants whose liquors contain but 2 grams per liter of phenol to come within scheme of recovery.—*R. E. Thompson.*

Solubility of Carbon Dioxide in Water. III. KURT BUCH. Nord. Kemistmötet. (Finland) 1928, 184–92; cf. Soc. Sci. Fennica Commentationes Phys.-Math., II, 16, 1924. From Chem. Abst., **23**: 2632, June 10, 1929. Object of investigation was to test validity of HENRY'S law at low concentrations and to determine whether the manner of mixing carbon dioxide, water, and air influence solubility of carbon dioxide. Conclusions: (*a*) HENRY'S law is valid from a carbon dioxide pressure of 1 or more atmospheres down to approximately $\frac{1}{20{,}000}$ atmosphere. Absorption coefficient of carbon dioxide is 0.83 at 20.8°. (*b*) Manner of mixing constituents does not influence solubility of carbon dioxide.—*R. E. Thompson.*

Solubility of Magnesium Hydroxide at Elevated Temperatures. A. TRAVERS and NOUVEL. Compt. rend., **188**: 499–501, 1929. From Chem. Abst., **23**: 2632, June 10, 1929. Solubility of magnesium hydroxide seems to diminish with temperature increase, becoming inappreciable at 178°. Solubilities at various temperatures from 35 to 200° are recorded.—*R. E. Thompson.*

A Note on the Determination of Minute Amounts of Iodine According to the Dupré-Winkler Method. J. AXEL HÖJER. Biochem. A., **205**: 273–96, 1929. From Chem. Abst., **23**: 2674, June 10, 1929. In water analysis, take 500 cc., add 0.5 cc. concentrated potassium hydroxide, and evaporate to dryness. Transfer residue to porcelain crucible or combustion boat if organic matter is high, and ignite in air until ash is white. Extract ash with four+2-cc. portions of alcohol and evaporate extract to dryness. Add 0.5 cc. water, boil few minutes and make acid to litmus with 0.5 N sulfuric acid, adding 0.1 cc. in excess. Add 1 drop saturated bromine water and evaporate to 0 1 cc. Add 0.2 cc. 2 percent starch solution and 0.03 cc. 0.4 N sulfuric acid and saturate with carbon dioxide. Add 0.1 cc. 6 percent potassium iodide and titrate with 0.003 N sodium thiosulfate.—*R. E. Thompson.*

Bacteriophage in the Water of the Don. D. BUYANOVSKII. Centr. Bakt., Parasitenk., I Abt., **110**: 120–5, 1929. From Chem. Abst., **23**: 2738, June 10, 1929. Water of Don has bactericidal effect on most members of intestinal group. Effect is destroyed by boiling. Property probably due to a bacteriophage.—*R. E. Thompson.*

Infected Ice Causes Discoloration of Halibut. F. C. HARRISON and W. SADLER. Food Industries, 1: 308–12, 1929. From Chem. Abst., 23: 2767, June 10, 1929. Yellow discoloration of halibut was proved to be due to growth of *Ps. fluorescens*. Principal sources of this bacterium are infected ice and fresh wash water on fishing boats. Organism was not present in sea water or on freshly caught halibut. Chlorination of water for ice-manufacturing purposes is advocated.—*R. E. Thompson.*

Suitable and Simple Methods of Potable Water Analysis. J. KABELIK and H. KABELIKOVA. Centr. Bakt. Parasitenk., I Abt., Ref. 90, 139–40, 1928; Wasser u. Abwasser, 25: 161, 1929. From Chem. Abst., 23: 2773, June 10, 1929. Treatise on water analysis methods.—*R. E. Thompson.*

Determination of Dissolved Oxygen in Water. BACH. Gesundh. Ing., 52: 36–7, 1929. From Chem. Abst., 23 2773, June 10, 1929. Following method was devised to simplify determination so that non-chemists might use it. Probable error is not more than 0.25 p.p.m. Dye which is decolorized by reducing agents is employed. At first the reducing agent is oxidized by the dissolved oxygen, but when latter is exhausted dye is decolorized. Reducing agent is ferrous ammonium sulfate and dye is phenosafranine. Five cubic centimeters alkaline tartrate solution (350 grams Rochelle salt and 100 grams sodium hydroxide in 1 liter) and 2 or 3 drops of phenosafranine (0.5 gram per liter) are added to 50 cc. water. Standard ferrous ammonium sulfate (2.15 grams per liter) is added until dye is decolorized. Care should be taken to prevent absorption of oxygen. One cubic centimeter is equivalent to 0.05 mgm. oxygen.—*R. E. Thompson.*

City of Hamburg Water Works. W. HOLTHUSEN and R. SCHRÖDER. Separate from "Industrie-Bibliothek" in 25 volumes. M. Schröder, Berlin. 14 pp.; Wasser u. Abwasser, 25: 168–9, 1929. From Chem. Abst., 23: 2773, June 10, 1929. Historical survey of Hamburg's water supply from 1370 to present time. Chlorine is added to sedimented water at rate of 0.4 to 0.8 gram per cubic meter and also to filtered water at rate of 0.15 to 0.6 gram per cubic meter. Purified water is often sterile and is always of excellent bacteriological and physical quality. Cf. C.A., 23: 224.—*R. E. Thompson.*

Purification of Swimming Pools by Chlorine. W. HILLAND. Gesundh. Ing., 51: 510–1, 1928; Wasser u. Abwasser, 25: 43. From Chem. Abst., 23: 2777, June 10, 1929. Usual brownish color of swimming pool was entirely removed by use of chlorine. Chloramine has 3 times the bactericidal efficiency of chlorine and is particularly efficient in destroying organisms of colon group. Chloramine is less odorous and is handled more readily than chlorine.—*R. E. Thompson.*

The Removal of Disturbing Substances in Drinking Water by Activated and Unactivated Carbon. FR. SARTORIUS and W. OTTEMEYER. Gesundheits-Ingenieur, 52: 529–34, July 20, and 546–50, July 27, 1929. Results are given of extensive laboratory experiments on dechlorination and dephenolization of

water with carbon. The authors recommend the employment of excess chlorination for the disinfection of water supplies which are subject to rapid changes in chlorine demand. In addition to insuring sufficient chlorine for sterilization, this method has the advantage of facilitating destruction of taste-producing substances. A corollary to the use of excess chlorine is a satisfactory and economical dechlorinating agent. The filters used consisted of cylindrical tubes 3 cm. in diameter and about 1 meter long, with an effluent opening somewhat below the middle of the tube. The tubes were filled to a depth of about 20 cm. with carbon, and the water was passed through in an upward direction. Three types of carbon were investigated, fir charcoal, coke, and zinc-chloride-activated AKT carbon. All 3 removed chlorine from water, the efficiency of coke being lowest, charcoal greater, and activated carbon tremendous. Some revivification occurred during rest periods. This recovery may be considered as a contact function of carbon which consists in converting the adsorbed chlorine into hydrochloric acid by means of free hydrogen formed on the surface of the carbon. Charcoal was easily and completely revivified with steam, coke only partially, and activated carbon to a considerable extent. The capacity during a second period of saturation, however, was somewhat diminished. Attempts at revivification by aëration and by ammonia treatment were unsuccessful. Experiments with charcoal of varying grain size and with varying concentrations of chlorine showed that the chlorine was adsorbed in conformity to the adsorption isotherm: markedly increased capacity with small sizes and relative diminution with higher concentrations. The smallest size used by the authors, i.e., 0.75 mm. diameter, may be regarded as the lower limit for practical purposes. No increase in efficiency could be noted from impregnating the carbon with colloidal iron hydroxide. With AKT carbon and water containing 0.5 p.p.m. chlorine, it was found that a flow of 0.016 liter per gram-minute could be dechlorinated completely. This is equivalent to 62.5 kgm. of carbon per cubic meter per minute of flow. This amount could probably be reduced materially by proper design of the filter. A suitable filter arrangement is suggested for domestic and war use. The taste of the water is not affected. The removal of phenol and chlorophenol in concentrations of 1 to 10 p.p.m. is not as readily accomplished. The latter is more strongly adsorbed than the former. Charcoal and coke, even with small grain size and at low rates of filtration, have no effect worthy of note. The limit of capacity of 50 grams of AKT cabron with a solution of 10 p.p.m. of chlorophenol lies at a velocity of 12 minutes per liter. This capacity is of somewhat limited duration. Experiments seemed to indicate that phenol was more readily adsorbed at 15° than at 0°. Experiments were also conducted on the chlorine demand of waters containing phenol and the effect of the presence of phenol on the efficiency of disinfection. It was found that 1 liter of water containing 10 p.p.m. of phenol absorbed 65 milligrams of chlorine in 8 hours and the greater part thereof in 3 hours. A considerable portion (over 50 percent with small concentrations) combines immediately. The temperature, within the limits of 0 and 30°, has no very important effect. Using water inoculated with *B. coli* after varying intervals of contact between the chlorine and phenol, it was found that the efficiency of a dosage of 6 p.p.m. of chlorine was practically destroyed after one-half hour by a phenol concen-

tration of 10 p.p.m., in 2 hours with 2 p.p.m., and in 8 hours with 1 p.p.m. The chlorine concentrations were determined by titration with N/100 sodium thiosulfate. A number of duplicate titrations were made using starch and alpha-naphthoflavone to compare the value of the two indicators. The requisite amount of sample was made up to 200 cc. with tap water and 5 cc. 50 percent acetic acid added, followed by a few grams of potassium iodide and a few drops of starch solution or 0.5 cc. alpha-naphthoflavone, and the solution titrated. Somewhat higher values were obtained with the latter indicator, as would be expected from its higher sensitivity. As pointed out by HAHN, SCHUTZ and PAVLIDES, who recommended the use of alpha-naphthoflavone in place of starch for the operator, this higher sensitiveness can only be realized when the reagent is used carefully, drop by drop. For example when using, 0.1 cc. of a 0.1 percent solution with 200 cc. of weakly chlorinated water, a weak tint is obtained which is difficult to titrate to a rose color, particularly in artificial light. With the recommended quantity of 0.8 cc. of 0.1 percent solution to 200 cc. of water, the tint is strong enough; but even under these conditions there are titration difficulties in artificial light and the values obtained are no better than those with starch. The authors obtained higher values than with the starch titration only when 0.5 cc. (or less) of alpha-naphthoflavone was used, the limits of error of the starch titration being usually under 0.1 mgm. per liter. The fading of starch from blue to colorless has the advantage of sharper contrast as against the gradual transformation in the rose color of the other indicator. Another point in favor of starch is the high cost of alpha-naphthoflavone, 15 Rm. for 5 grams. Starch is therefore considered the more suitable indicator.—*R. E. Thompson.*

Chloramine-T. R. A. FELDHOFF. Pharm. Ztg., **74**: 756–7, 1929. From Chem. Abst., **23**: 4020, August 20, 1929. A review of the properties and method of manufacturing the D. A. B. 6 preparation known as "Chloramin-p-Toluolchloramidnatrium."—*R. E. Thompson.*

Heat Measurement and Water Imperviousness in Concrete. RUD. G. GÖSCHWITZ. Zement, **17**: 1723–5, 1928. From Chem. Abst., **23**: 4040, August 20, 1929. A description of apparatus for these measurements.—*R. E. Thompson.*

Extraction and Recovery of Phenols from Ammonia Liquor. ROBERT M. CRAWFORD. Proc. 2nd. Intern. Conference Bituminous Coal **2**: 726–34, 1928. From Chem. Abst., **23**: 4046, August 20, 1929. The solvent extraction method for the substantial elimination of phenols from ammonia liquor and their recovery as a salable by-product in the form of crude tar acids is outlined and apparatus described. The free phenols are extracted with solvents such as benzol, motor fuel, or coal-tar light oils, removed from the solution by passing the latter through sodium hydroxide solution, and then recovered by neutralization of the phenolate formed.—*R. E. Thompson.*

The Prevention of Boiler Corrosion by the Addition of Alkali. A. SPLITTGERBER. Die Chem. Fabrik., **21**: 253, 1929. Author refers to article in

"Vom Wasser" (1928, II, 92–127), in which he summarises the literature on treatment of boiler waters, and quotes his reasons for belief that gas-free, non-alkaline water will, invariably, attack iron and that a minimum alkali content is therefore necessary. In American and German practice, this alkali addition is provided for. Either sodium carbonate or sodium hydroxide may be used, but these are not identical in their protective action. The Association of Boiler Owners therefore gives the following rule for estimating the "soda-number" which should be between 400 and 2000. Soda-number = $\frac{\text{soda}}{4.5}$ + caustic soda (NaOH); both concentrations expressed as mgm. per liter. Embrittlement caused in riveted boilers by concentration of caustic soda in the seams can be obviated by keeping a certain balance between alkali and sulphate. The sulphate has to be added in neutral soluble form and the proportion necessary increases with the pressure. PARR and STRAUB suggested from laboratory experiments that alkali phosphates would serve the same purpose at a concentration 500 times less than of sulphate. The decomposition of sodium carbonate at high temperatures into caustic soda and volatile carbonic acid completely dislocates the sulphate-carbonate relation, whereas phosphates give no volatile dissociation product. SPILMAN found the same favourable effect with sodium aluminate, which coagulates organic substances into a light floc which remains in suspension. Attempts to estimate the "soda-number" by separate titrations of carbonate and hydroxide using different indicators have proved difficult, owing to colour or turbidity in boiler water. The degree of acidity can be measured by hydrogen ion concentration determination, but to be of use, the degree of buffering of the solution must also be known. With rising temperature the pH value alters, so that, for example, the same soda-number for a boiler water (400 mgm. /1. NaOH) is found at 20° if the pH value is 12.1 and at 70° if the pH value is 10.8. This is important when hot boiler water is to be tested. Curves and tables are given showing this rise in pH value and the rise in content of NaOH (taking this as the cause of alkalinity) at 20° and 70° for each unit or 0.1 rise in pH value.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Boiler Feed Water Treated with Permutit and Boiler Scale containing Silica. K. BRAUNGARD. Z. des Bayer. Revisions Vereins, **29**: 259; Wasser u. Gas. **17**: 950, 1927; Wass. u. Abwass., **24**: 270, 1928. Boiler water should never be so far evaporated that saturation point for silicic acid is reached. As silicic acid in presence of soda forms soluble sodium silicate, feed water should always possess a certain amount of soda alkalinity. When waters of average hardness have been treated with permutit, concentration of alkali can increase fifteen to twenty times without any harm, provided hardness removal complete.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Deconcentration: an Aspect of Boiler Control. Technicus. Chem. Age., **20**: 443 and 465, 1929. Notwithstanding any treatment which boiler feed or make-up

water may receive, increase in saline concentration in boiler water requires attention. Foaming, or formation of permanent scum, is due to the presence both of suspended matter and of soluble salts. Priming, or bumping, carries saline material to other parts of the plant and causes trouble. The concentration of salts in boiler water increases very rapidly. It is calculated that in a boiler using 200 gallons per hour of make-up water containing 10 grains per gallon, the concentration would increase to 100 grains per gallon after 10 days steaming. Softening does not prevent, but increases, the concentration of sodium salts which can, however, be reduced by steam purifiers, by evaporated make-up water, or by periodical or continuous blow-down. Steam purifiers reduce only the quantity of saline matter passing out with the steam. The other three processes reduce the salt concentration in the boiler. The process by evaporation most nearly approaches the ideal; but boiler concentrations must still be examined. There are many types of evaporators. With periodical blow-down, a limiting concentration must be decided upon, which should be about 200 grains per gallon for modern high pressure boilers. A formula is given for calculating the blow-down fraction. Continuous blow-down has the advantage not only of tending to reduce both scale and sludge formation, but also of recovering the greater part of the heat in the blow-down.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Progress in Treatment of Boiler Feed Water. Br. Schutz. The Fuel Economist, **4**: 539, 1929. Boiler feed water must be de-aërated, in order to prevent corrosion. Previous methods have consisted in preventing stored condensed water from coming in contact with the atmosphere by steam or gas cushions, or in absorbing the oxygen with iron turnings, or in special filters. The new de-gasifying process of Morawe (German patent 388,128) uses neither of these devices. Water is passed through a heat exchanger to a tank which is under reduced pressure. Here the water boils at 60°C. and all dissolved gases are expelled and drawn away by vacuum pump. Natural waters for boilers, if hard, have to be softened either by lime-soda, or by permutit process. The evaporation process is not altogether satisfactory, even after chemical pre-treatment, because distilled water is acid and corrosive. At several plants, the Morawe de-gasifying plant has been installed in conjunction with, or in place of, evaporating plant, and has given very satisfactory results. The water for the greatest boiler plant in the world, at Detroit, is purified with permutit and degasified by countercurrent steam, which removes not only dissolved carbon dioxide and oxygen, but also some bicarbonate carbon dioxide.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Laboratory Experiments on the Purification of Water from the River Meuse and the Water Supply of the Town of Lüttich (Liège) for use as Boiler Feed Water. G. Batta and C. Rorive. Rev. universelle Mines, Metallurgie, Travaux publics, etc: (8) **1**: 125 and 164, 15/3; Chem. Zbl., **100**: 2217, 1929. As both the Meuse water and the Lüttich town supply are frequently used in

boiler plants, it was necessary to discover the most suitable treatment for them. W. SPRING and E. PROST had already examined the composition and properties of Meuse water. It contains large quantities of calcium carbonate and calcium sulphate. The Lüttich water contains bicarbonate. Lime and soda treatment was found to be the most rapid and suitable and to prevent corrosion of the boiler, or of any part of the system.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

A New Portable Chlorinator. R. V. DONNELLY. Canadian Eng., 56: 36, 1929. A Paradon dry feed chlorinator with gauges, control handles, and auxiliary equipment, is contained in a portable oak cabinet. Chlorine can be supplied from the 12-pound cylinder against pressures up to 25 pounds per square inch and any desired capacity from 0.4 pound to 300 pounds of chlorine per 24 hours can be obtained. The portable chlorinator is very useful for sterilising mains before use, and dead-ends. It was originally designed for the water department of Syracuse, N. Y., and has been used with success for several months.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

The Cause of Corrosion in Boilers. M. GROECK. Gesund. Ing., 52: 23, 411, 1929. The solution of metals being an electrolytic process, iron of non-homogeneous structure in contact with tap water forms a typical corrosion element, parts of lower potential forming the anodes, parts of higher potential, the cathodes, while the water is the electrolyte. The author's aim is to show that the occurrence of the action depends on different conditions of the water and not on the material. If anodic iron goes into solution, hydrogen is expelled at the cathode forming an adhesive layer, altering its potential, and thus, by eliminating potential difference, stopping the current, and, therefore, the corrosion. Should this hydrogen layer be disturbed by the presence of a stronger electrolyte than water, or by the effect of oxygen prevent, the action continues. In still water, oxygen, because of its low power of diffusion, does not have much effect. Thus corrosion in a boiler should be increased by increased frequency of feeding, through action of resulting increased supply of oxygen. This theory, however, fails, when the material is taken into consideration; for according to it the corrosive action would not be increased with a bad (that is, a less homogeneous) iron; the degree of hydrogen formation would then be greater and the protective effect, therefore, equally strong. The theory would therefore be false, if these circumstances were the only source of corrosion. There exists, however, even wider destruction in the form of pits and holes in the metal. The corrosion products forming at the anode are precipitated in the presence of oxygen as ferric hydroxide, which is anodically deposited as rust nodules. According to EVANS's theory, if parts of the iron are differently aërated, those parts which are not in contact with oxygen go into solution, the oxygen depositing a protective coat of oxygen, or hydroxide ions, on the parts with which it is in contact, thus raising their potential. The metal parts under the rust nodules are therefore un-aërated

anodes and undergo severe corrosion, even when the water is at rest. Corrosion may also be caused by local deposits of scale, though an even deposit acts as a protective layer. It is suggested that the harmful effect of both rust and scale might be diminished by the continued removal of oxygen from the water. Experiments will be carried out to see whether this hypothesis is sustained in practice.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

The Action of Water and Solutions of Salts on Zinc and Lead Water Pipes. E. FRISTER. Tech. Gemeindebl., 32: 11, 156, 1929. The peculiar destruction of water pipes in a dwelling house led the Section for Metallography of the Board of Assayers in Dahlem to investigate the action on zinc and lead of distilled water, rain-water, tap-water, tap-water softened by the Permutit process, tap-water with calcium sulphate and calcium sulphite (saturated and unsaturated solutions), and artificial sea water. Tables are given of the effect and manner of action of the different solutions on zinc and lead plates in experiments lasting 63 days. Zinc was most severely attacked by rain-water. Action of distilled water, softened tap-water, and sea water was only half as strong. Ordinary tap-water and tap-water with added calcium sulphate or sulphite showed comparatively little action. The action of salt-containing waters was mainly local while rain-water and distilled water attacked the zinc evenly. Experiments over longer periods showed that a protective coating formed on zinc in contact with distilled, tap, or sea-water. This also appeared when falling rain was allowed to dry off quickly and did not remain in contact with the zinc. Experiments with calcium sulphate and sulphite solutions showed that their corrosive action increased up to a certain concentration (sulphate, 0.4 gram; sulphite, 0.096 gram per liter) and diminished with higher concentrations. The corrosion was local and pitting of the metal occurred. Solutions of calcium hydroxide and of sodium carbonate showed strong evenly distributed action; the strongest action with sodium carbonate resulted from solutions containing 3.5 to 7 grams per liter. Similar experiments were carried out with lead plates. Again, rain water showed the strongest action. With tap water, a protective covering quickly formed. Distilled water acted in two different ways, according to the content of carbonic acid. If this was high, a white efflorescence appeared on the surface of the lead, especially on places weakened by bending. This stopped forming after a certain time. The lead surface was etched but not destroyed. With low carbonic acid content, a white scum appeared on the surface of the water, sank, and was continually renewed. Crystals of lead hydroxide and lead oxide separated and the lead plate was eaten away. With calcium sulphate solutions the action was slight, increasing with the concentration to a certain point and decreasing with further concentration. With very dilute calcium hydroxide the action was strong, with 0.135 and 0.0675 gram per liter it diminished, and rose again with higher concentrations. Sodium carbonate solutions showed weak action, varying like that of calcium hydroxide.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

The Treatment of Cooling Waters. W. KARSTEN. Die Chem. Fabrik, 22: 269, 1929. Scale is deposited primarily as a result of temporary hardness in cooling water. The most troublesome scale former is $CaSO_4$ which however can become sufficiently concentrated to be deposited only where cooling water is re-cooled over cooling towers and re-circulated. Addition of acid may not be of use in this case, but additions of certain substances have been successful. Deposits on cooling surfaces may be removed either mechanically, or by chemical means, but the surface is seriously damaged in either case. Illustrations of damage done to pipe walls by cleaning are given. By the BALCKE "Inoculation" Process (D.R.P.), "inoculation acid" (hydrochloric acid) is added to liberate carbonic acid from such portion of the bicarbonate that the remainder will not be precipitated even when the water is warmed. In works where cooling water is re-used, the added water is treated. A diagram of the treatment plant is given. The amount of addition is self-regulating according to the amount of added water. Under conditions of varying hardness, it is necessary to carry out regular titrations both of the added water and of the circulating water, to avoid adding excess of acid. A special control apparatus is used to indicate over-acidification of the added water.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Filter Effluent Control at Montreal. C. G. RICHARDSON. Canadian Eng., 56: 615, 1929. The rates of flow at the new rapid sand filtration plant at Montreal, with a normal daily capacity of 120,000,000 gallons, are automatically regulated by means of control valves. Each filter is fitted with the usual Venturi tube for measuring loss of head and rate of effluent flow, but a new unit of "pendulum-diaphragms," in place of the mercury float wells has been installed. It is possible to set the rate of flow on any individual filter by operating a five-way valve, which admits water to, or withdraws water from, a float pipe in connection with a regulating float. There is also a main control tank for regulating the rate of flow in all the filters at the same time. The operator sets the dial on the central table to the desired rate, moves a handle to regulate the level of the water in the main control tank, which is connected with each individual control tank, and thereby automatically controls the rate of flow throughout the whole plant. The newly designed unit consists of a diaphragm, which moves in proportion to the differential pressure, and a pendulum, connected by a piston rod and cross head to the diaphragm, which magnifies and transmits movements by means of a cam and a pulley with a cable, to the gauge on the operating table. This unit occupies less space than the mercury float wells and is more reliable because there is no mercury to be blown out by sudden high pressures on the effluent line. A diagram of the diaphragm unit is given.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

German Exhibition "Gas and Water" in Berlin from 19th April to 21st July, 1929. III. H. STADLINGER. Chem. Ztg., 53: 45, 439, 1929. Water Purification. The exhibit of the Permutit Company (Berlin) included the newest neo-Permutit filter, double filter for iron-removal, two-chamber silica

filter, and household filters. The green-black neo-Permutit, now used in place of the white sodium-Permutit, is much more rapid in action and, owing to its higher specific gravity, loss of material is smaller. Regeneration with sodium chloride is also much quicker. In addition to the large industrial filters, 15 different sizes for trade and household use are supplied. Another novelty of the firm is a de-aëration plant. The Bamag-Meguin Company (Berlin) show a "Deactivator" on the BÜCHER system in which acidity is controlled by introduction of a calcium hydroxide solution of definite concentration. This firm also shows a two-phase iron-removal plant, a sterilising plant, and an apparatus for adding solutions of chemicals in a uniform stream and in accurately measured quantity. **Filtration Plants.** The Bamag-Meguin Company show a revolving screen for the removal of rough impurities from raw water, consisting of rectangular frames covered with fine wire mesh and fixed on an endless travelling band. Other exhibits are the Bollmann rapid sand filters, the Berkefeld filters, and the candle-shaped filter apparatus of the Martini and Hüneke Company of Berlin.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Experiences in Tracing Sources of Water by Fluorescent Colouring. F. EGGER. Z. angew. Chem., **42**: 22, 623, 1929. The Chemical Experimental Station at Stuttgart has collected the results of much experience in the detection of fluorescent colouring which do not entirely agree with the literature. Neither by the SCHARDT Fluoroscope, nor by observations in a dark room, was it possible to detect fluorescence in greater dilution than 1:1000 millions. By OHLMÜLLER'S process, this limit could be raised to 1:10,000 millions. Air free from dust and soot and clear sunlight are necessary for satisfactory results. The solution of colouring matter, however, must not be exposed to direct sunlight. A high candle power lamp was found to be better than the Heräus Ultra-lamp. Fluorescence in the apparatus was troublesome with the more dilute solutions.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

The Development of the Venturi Flume. ALEX. H. JAMESON. Water and Water Eng., 32: 375, 105–107, March 20, 1930. Approach is mathematical. Description of what is probably the first full-sized Venturi flume in England, consisting of a long stream-lined "hump" one foot high in bed of a trapezoidal concrete channel without side contractions. Accuracy of measurement is believed to be within 0.5 percent for rates of flow from 217 to 100 second-feet; within 1 percent, at 30 second-feet; and within 2 percent, at 7 second-feet. Venturi flumes of "standing wave" type have been in use more than twelve years by the Indian Irrigations Departments; one such flume on the Nira Right-Bank Canal can discharge 1750 second-feet. The advantages of Venturi flumes over sharp edged weirs are: great saving in head; freedom from silting up; coefficient unaffected by sharpness of edge of weir; and less tendency to leak, as loss of head is so much less. On the Fort Lyon Canal in Colorado, a 40-foot Venturi flume discharges 1800 second-feet. Theory of the Venturi flume is discussed briefly.—*Arthur P. Miller.*

Water Works Construction. M. R. BARNETT. Water and Water Eng., 32: 375, 108–114, March 20, 1930. First principle in construction of a pipe-line is that it must be as nearly as possible coincident with hydraulic gradient. That is, it must be as nearly straight as possible. Loss of head occasioned by kinks cannot be ignored. Some designers prefer to construct their lines altogether of pipes under pressure; others use as much culvert as possible, resorting to pipes only for crossing deeper valleys. Use of pressure line may shorten route with great advantage. An important point is to ensure for the water free entrance at inlet end and free exit at outlet end. Many difficulties and interruptions in service can be traced to neglect of these fundamental principles. Frequent causes of pipe-line failure are: (1) careless handling of the pipes, in transport, or otherwise; (2) back-filling with other than fine material, causing "star" cracks from stones; (3) over loading pipe lines when laying; (4) laying pipes on bare rock bed; (5) opening new trench alongside an old line, which may split when side pressure support withdrawn; (6) laying pipes along the side of steeply sloping ground. Some bursts are due to inequality in wall-thickness to which defect horizontally cast pipe is more exposed. In cities and towns, water pipes laid transversely to other pipes or culverts, particularly two such pipes in actual contact, are somewhat susceptible to fracture from vibrations set up by heavy traffic. Building a pipe line of small diameter solidly into the walls of a brick manhole intersected by it results sometimes in fractures. Occasionally when an excessive load, such as a new steam boiler on a truck, crosses a water main, a break will result. Leakage of current from electric cables "burns" through pipe. Author is inclined to believe that strengthening of modern road surfaces to meet increased weight of traffic has increased possibilities for fractured mains. His reason is that more is now removed of soft sub-soil which formerly acted as cushion between the traffic load and water main, deadening destructive vibration; while what is left has become harder and therefore more transmissive.—*Arthur P. Miller.*

River Pollution by Artificial Silk Works. ANON. Water and Water Eng., 32: 375, 113–114, March 20, 1930. Pollution resulting from manufacture of artificial silk still gives difficulty in various parts of England, leading in some cases to litigation. Two great obstacles to improving these conditions are (1) expense and (2) ignorance of proper methods of treatment. Local authorities desire when possible to help manufacturers by permitting access of wastes to sewers; but under the general law the right of discharging such wastes to sewers is qualified by two wide provisos: (1) facilities need not be given where sewers, or sewage disposal works, are not large enough to care for the wastes; (2) wastes need not be received if they would be harmful to the sewers or to the sewage treatment processes.—*Arthur P. Miller.*

Water Prospecting in the Deccan Trap Country. S. K. ROY. Water and Water Eng., 32: 375, 126–128, March 20, 1930. Discusses geology of the Bandsa State and possibility of procuring ground water under geological conditions existing in Deccan Trap Country. Gives in detail discussions of considerations controlling choice of well sites.—*Arthur P. Miller.*

Guildford Corporation Waterworks. Opening Chalk Fissures by Dynamite. ANON. Water and Water Eng., 32: 375, 128–129, March 20, 1930. To increase the flow from a borehole 24 inches in diameter, 400 feet deep, the lower 200 feet being in chalk, a deflected boring 6 inches in diameter was driven from a point 265 feet below surface for a length of 60 feet. Dynamite was exploded in the deflected borehole, causing an increase in the flow of water. A second deflected boring was then driven in another direction. Exploding this resulted in additional water. This well now supplies about 65,000 gallons per hour, whereas before treatment it was practically a failure.—*Arthur P. Miller.*

A Quantitative Study of the Effect of Ultra-Violet Rays upon the Bacteriophage (and B. Coli). S. L. BAKER and S. H. NANAVUTTY. Brit. J. Exper. Path., 5: 10, 45–61, 1929. Bulletin of Hygiene, 4: 11, 910. November, 1929. The susceptibility of *B. coli*, certain bacteriophage filtrates, and certain ferments to ultra-violet radiation was tested. The survival curve for *B. coli* when killed by disinfectants or heat shows a logarithmic decrease over the greater part of its course, flattening out as it approaches the base line. On the other hand, the death rate of *B. coli* subjected to the action of ultra-violet light increases, so that the curve found by plotting the logarithms of the numbers of surviving cells is convex upwards and to the right. The lethal effect of irradiation on *B. coli* and bacteriophage and its inactivating effect on ferments were compared. Assuming the lethal exposure for *B. coli* as one, that required to kill or inactivate the other agents tested varied from 2 for SHIGA bacteriophage to about 120 for diastase and lysozyme. Results of experiments with varying wave lengths tend to support the view that the bacteriophage is more of the nature of a virus than of a ferment.—*Arthur P. Miller.*

Report on Rural Water Supplies, Advisory Committee on Water. Ministry of Health. 1929. London. From Bull. Hyg., 4: 11, 930, November, 1929. Rural districts are more and more demanding piped water supplies. Lack of these is giving increased impetus to rural migration to towns. In 1924 the Ministry of Health (England) submitted a memorandum on this question to many competent authorities; the suggestions received in reply are given, as well as a review of the present state of affairs. Legal, financial, hygienic, and technical aspects of the subject are discussed. To rural local authorities this report should be of much value.—*Arthur P. Miller.*

Thirty Years' Work of the Paris Water Examination Service. F. DIÉNERT. Ann. d'Hyg. Pub., Indust. et Sociale, 7: 381–402, 1929. From Bull. Hyg., 4: 11, 931, November, 1929. A typhoid fever outbreak in Paris in 1900 brought about a change in the water examination system. Laboratory work was supplemented by field work on the watershed. By means of salt, fluorescein, yeast, and *B. coli* cultures, a study was made of the sources of replenishment of the under-ground water and of the travel of sub-surface water. The assistance of practising physicians and others was enlisted in connection with the reporting of infectious diseases occurring on the watershed. Analytical data on, and the electrical resistivity of water from all parts of the catchment area were recorded, to be used with routine analyses as indicators of the sources of

water used. The electrical resistivity has been found particularly useful, because any change in the source of supply is shown at once and possible danger foreseen.—*Arthur P. Miller.*

Phosphate as a Criterion of the Degree of Pollution of Water. E. REMY. Arch. f. Hyg. u. Bakt., **101**: 366–8, 1929. From Bull. Hyg., **4**: 11, 932, November, 1929. Although there is present in sewage phosphorus, both in organic combination and as phosphate, there is no parallelism between degree of pollution indicated by permanganate, nitrogen, or oxygen demand tests and that indicated by the phosphate. This was proven by examination of samples of sewage, pool water, and river water.—*Arthur P. Miller.*

Measurement of Turbidity of Waters. H. ILZHÖFER. Arch. f. Hyg. u. Bakt., **101**: 1–4, 1929. From Bull. Hyg., **4**: 11, 932, November, 1929. In the WEBER photometer, the glass cylinder with removable glass cover containing sample slides into sheet metal container wth osmium lamp at one end. The emergent light falls on a white paper and is compared photometrically with light from a similar apparatus filled with clear water. This apparatus can serve as a measure of turbidity.—*Arthur P. Miller.*

Theory of Chlorination of Water. A. WOJTKIEWICZ, E. MISCHUSTIN, and E. RUNOW. Cent. f. Bakt. II. Abt., **77**: 21–38, 1929. From Bull. Hyg., **4**: 11, 933, November, 1929. Only a very small part of chlorine added to water is taken up in the lethal action. Chlorine absorption depends in part on the presence and concentration of electrolytes and on the chlorine dose. Ammonium chloride in small amounts hinders chlorine absorption, but in greater strength has a marked catalytic effect. Salts of heavy metals added in doses too small to poison bacteria increase sterilizing effect of chlorine, but if the concentrations are very low, reverse obtains. Partial sterilization stimulates the surviving organisms. Chlorine gas is more effective at normal temperatures (18°C.) while chloride of lime is better at higher temperatures (35°C).—*Arthur P. Miller.*

Influence of Temperature on Chlorine in Water. G. W. SCHMIDT. Arch. f. Hyg. u. Bakt. **101**: 290–296, 1929. From Bull. Hyg., **4**: 11, 933, November, 1929. Experiments were made to determine effect of temperature upon rate of disappearance of dissolved chlorine from solution. Various raw waters, chlorinated water, raw and sterilized sewage, as well as solutions of galactose and asparagine were used. Although chlorine absorption increases with rising temperature, the effect is small as compared with that of initial dose and of conditions of storage.—*Arthur P. Miller.*

Sterilization of Waters by Chlorine. F. DIENÉRT and P. ÉTRILLARD. Compt. Rend. Acad. Sci., **88**: 826–9, 1929. From Bull. Hyg., **4**: 11, 933, November, 1929. The authors have been unable to detect any radiation emitted by chlorine during the sterilizing action, to which is sometimes attributed the actual destruction of bacteria. On the other hand, sterilizing action

is impaired if a dechlorinating substance is added to the water before chlorination. On the radiation hypothesis one would expect germicidal radiation when chlorine combines with a dechlorinating substance, such as thiosulphate. Seine water treated with 0.2 p.p.m. of chlorine is sterilized in from 2 to 24 hours, depending on amount of organic matter present. The same effect is achieved if the remaining chlorine is removed by thiosulphate 5 minutes after chlorination. This result suggests that the chlorine is absorbed quickly by the bacteria, but that the organisms live for some time after absorbing a lethal dose.—*Arthur P. Miller.*

Destruction of Bacteria by Small Doses of Chlorine when the Water is Strongly Shaken, and by Finely Divided Metals. E. TECHOUÉYRES. Rev. d'Hyg. et de Med. Preventive, 51: 393–425, 1929. From Bull. Hyg., 4: 11, 934, November, 1929. In Reims the water supply is obtained from wells in subjacent chalk. Increased population in neighborhood of wells makes pollution inevitable. Residual chlorine up to 0.3 p.p.m. does not impart taste. Bactericidal action is better if water is agitated during and for some time after chlorination. Even without chlorine, agitation produced in centrifugal pump has sterilizing effect. This has been traced to presence of finely divided copper. Copper, bronze, brass have sterilizing effect; lead is much less active; tin and antimony are quite inactive.—*Arthur P. Miller.*

Taste on Chlorinating Water Containing Phenol. F. DIÉNERT and F. WANDENBULCKE. Ann. d'Hyg. Pub. Indust. et Sociale, 7: 298–301, 1929. From Bull. Hyg., 4: 11, 934, November, 1929. Using Rungis spring water, it was found that phenol present in excess of 1 part in 10^{10} will cause taste on chlorination. Testing immediately after chlorination, it was found that degree of taste increased with increasing phenol content. With an increasing chlorine dose up to about 0.6 p.p.m., taste increases, whatever be the phenol content. With phenol content of 1 in 10^7 or 10^8, the taste, after increasing to a maximum with increasing chlorine dose then becomes less and disappears at 1.6 p.p.m., chlorine in the case of 1 in 10^8, and something over 2 p.p.m. in the case of 1 part in 10^7. For phenol present in quantities greater than 1 in 10^6, no lessening of taste with increasing chlorine dose could be observed. Filtered Seine river water gives a taste which increases with the dose of chlorine and phenol content. Consequently, obtaining such results as above given depends somewhat on the kind of water used in the tests.—*Arthur P. Miller.*

Salicyl Compounds as a Cause of Iodoform Taste in Chlorinated Water. B. A. ADAMS. Med. Officer, 42: 71–2, 1929. From Bull. Hyg., 4: 11, 935, November, 1929. Salicylic acid and many of its congeners give an iodoform taste to water. Salicin, methyl salicylate, acetyl salicylic acid, and coumarin do not. Salicyl aldehyde and salicyl alcohol in concentration of 1 in one thousand million will give water a stronger taste than phenol in the same concentration. Willows and poplars will give an iodoform taste on chlorination of water which has been in contact with them, but apparently trees other than members of the Salicaceae family do not have this effect.—*Arthur P. Miller.*

On the Effect of Potassium Permanganate in Eliminating Iron from Drinking-Water. C. P. MOM and O. H. VAN DER HOUT. Meded. Dienst. d. Volksgezondheid in Nederl.-Indie, 17: 550–60, 1928. From Bull. Hyg., 4: 11, 936, November, 1929. Iron pre-existing as ferrous bicarbonate is usually precipitated as ferric hydroxide as result of atmosphereic oxidation, but may remain colloidally dispersed. Transition from sol to gel is dependent mainly on pH, taking place the more readily, the higher the pH. With constant pH, transition is assisted by presence of substances such as ferric hydroxide gel, or manganese dioxide. When ratio $[HCO_3]$: $[Cl] + [SO_4]$ is less than 1, iron elimination is less complete. In removal of ferrous iron more oxygen disappears than is required to oxidize the iron; it appears that oxygen as well as ferric hydroxide is adsorbed by contact substances. Removal is more complete when oxidation is effected by permanganate than by chlorine or hydrogen peroxide.—*Arthur P. Miller.*

NEW BOOKS

Ninth Annual Report of Ohio Conference on Water Purification, Columbus, October 24–5, 1929. 107 pp. Address of Welcome. C. A. NEAL. 7–11. Charts are given showing typhoid mortality rate in Ohio from 1895 to 1929 and in Cincinnati from 1895 to 1927 and population supplied with filtered water in Ohio from 1895 to date. There is an absolute, direct relationship between increase in population served with pure water and reduction in deaths from typhoid fever. Since 1895, typhoid death rate in the state has decreased from 41.5 to 1 per 100,000 and population supplied with filtered water has increased from zero to nearly 3,700,000. Typhoid death rate in Cincinnati in 1885 was 140 per 100,000 the average rate for ensuing 20 years being about 50. A marked decrease to 17 occurred in 1908 following first full year's operation of water purification plant and for past 15 years rate has averaged about 3. Practically every case in recent years has originated outside the city. **Disposal of Sludge at Water Softening Plants.** CHARLES C. WHYSALL. 27–9. The Marion deep well water supply, which has hardness of over 700 p.p.m., is softened by lime-soda process. Approximately 4,200 pounds of sludge containing 75 to 80 per cent moisture is discharged daily from the Dorr clarifier, flow treated being in excess of 1 million gallons per day. Disposal of the sludge, which is very difficult to dry, is a problem. Moisture content can be reduced to 50 percent by vacuum filtration. In discussion it was stated that an investigation carried out by the State Fish and Game Commission indicated that lime-soda process sludge is not harmful to fish. **A New Disinfectant for Small Filter Plants.** J. H. MILLER. 29. H-T-H (high test hypochlorite) is now employed for chlorinating the water at Beulah Beach plant, which has a capacity of 200,000 gallons per day. H-T-H is a stable, easily soluble, free flowing powder, containing 65 percent available Cl_2. It produces practically no sludge and contains only about 0.5 percent $CaCl_2$, as compared with from 25 to 30 percent ordinarily present in bleaching powder, and is consequently non-hygroscopic. The cost in small quantities is practically the same as that of bleaching powder. **Return Bends to Replace Strainers.** THOMAS H. LARKINS. 30. During overhauling of the East Liverpool filters, sand of which

had become badly encrusted with a black deposit consisting chiefly of Mn and Fe, the old brass strainers were replaced with 180°-bends and crushed limestone was substituted for the larger sizes of gravel. The cast brass 180°-bends cost only 26 cents each, as compared with 41 cents for mushroom type strainers. One filter has been in operation 8 months and appears to be in good condition. In discussion, L. H. ENSLOW stated that use of 180°-bends at the Miraflores, Panama, plant resulted in poor distribution of wash water. Many hard spots developed in sand beds until difficulty was overcome to a certain extent by rebuilding the filters, using 30 inches of gravel. CLARK stated that similar bends were used at Decatur, Ill., when rate of wash was increased from 12 to 24 inches per minute. Control of wash water distribution was maintained by limiting the openings in the bends to 0.3 percent of filter area. **Device for Leveling Gravel in a Filter Without Removing the Sand.** J. R. LOWER. 31–3. An investigation carried out to determine cause of hard spots and uneveness of washing in one of filters at Upper Sandusky revealed the fact that sand depth varied from 23 to 35 inches, although surface was practically level. The hard spots were in sections where sand was deepest. The shallow sand areas washed quickly and easily. A simple device designed for leveling the gravel during backwashing is described briefly and illustrated. Leveling of gravel enabled filter to be washed more uniformly with less wash water. **Methods of Handling Sand and Gravel in Rebuilding Filters at Akron.** J. S. GETTRUST. 33–5. Procedure followed in cleaning filters at Akron is described. Sand is first removed and stored in another filter. The rest of the material is then passed through a Nichols sand ejector to a revolving screen, 3 feet in diameter and 9 feet long, operated at 13 r.p.m., in 4 sections, discharging sand and three different sizes of gravel into separate bins. The material in passing through pipe to screen is thoroughly scoured. A water spray plays on outside of last 3 sections of the screen to assist in cleaning and separating the larger material. Each filter is of 2 million gallons per day capacity, has area of 700 square feet, and contains 85 cubic yards of material. The 30-inch sand bed is supported by 10 inches of graded gravel over the pyramidal depressions which hold the balls and marbles of the Wheeler bottom. Two men can clean one unit in 17 days. The maximum rate of wash which can be employed is from 18 to 21 inches, which is insufficient to prevent formation of hard spots indefinitely. **An Automatic Buret for Use in Determining Carbon Dioxide in Water.** E. J. LEWIS. 35. Brief description of an automatic buret which prevents atmospheric CO_2 from coming in contact with the N/44 NaOH. The NaOH solution is covered with a layer of Nujol. **Artificial Gas in the Laboratory.** 35–6. Brief data are given regarding experience with two types of fuel gas supplied in cylinders: McNey gas, which requires the use of special burners, and Pyrofax, which can be used with ordinary burners. The former has a B.t.u. value of 3,200 and costs $7.40 per 100 pounds and the latter, a B.t.u. value of 2,800 and costs $14.00 per 100 pounds. **Pipe Corrosion Problem at Leroy.** 36. Pitting of hot water pipes by lime-soda softened water at Leroy and with excess-lime treated water at Youngstown was reported. **Description and Operating Results of the Water Purification and Softening Plant at Fremont.** GEO. M. LIEBER. 37–44. A detailed description of the new filtration and softening plant at Fremont, which consists of intake on west bank of

Sandusky River, raw water aërator with 26 Sacramento-type nozzles, 2 mechanical mixing tanks providing detention period of about 30 minutes, Dorr clarifier, 2 sedimentation basins, 2 carbonation basins with drilled pipe CO_2 distribution systems, four 0.75-million gallon per day rapid sand filters, chlorination apparatus, and clear well. The filtering material consists of 25 inches of sand supported on a 2-inch layer of torpedo sand and 19 inches of graded gravel. Wash water tank has capacity of 30,000 gallons, providing for 7½-minute wash at rate of 24 inches vertical rise. Excess lime treatment is employed to obtain maximum reduction in alkalinity, the soda ash feed being then regulated to produce the desired hardness. The policy adopted at first of delivering water with hardness of 100 p.p.m. resulted in complaints from consumers; consequently hardness is now being reduced to about 85 p.p.m. Daily average filtered water alkalinities as low as 18 p.p.m. have been obtained. The average total alkalinities of the raw and filtered waters during September, 1929, were 146 and 23 p.p.m.; the total hardnesses, 272 and 84; and the Mg contents, 23 and 2 p.p.m., respectively. During same month filter runs averaged 48 hrs., and wash water 1.74 percent. **Swimming Pool Sanitation.** J. S. SHUEY. 45–51. Discussion of the sanitation of swimming pools, with particular reference to conditions in Cincinnati. The quality requirements in Cincinnati are that median 37° count shall not exceed 1000 per cubic centimeters and that not over 25 percent of samples collected during any month shall show positive presumptive test for *B. coli* in 10 cc. If 2 successive samples collected on different days show a positive presumptive test, pool is closed until laboratory reports on further samples are satisfactory. A new standard which has been worked out in coöperation with representatives of Detroit and Cleveland, and which, it is expected, will be adopted on January 1, 1930, is described. Under this plan, samples giving a total bacterial count greater than 200 per cubic centimeter, or a positive presumptive test for *B. coli* in 10 cc., would be considered unsatisfactory. Ratings on the basis of these tests would be issued monthly, using 1000 as a perfect score, and deducting the proportion of this score represented by the number of unsatisfactory samples. Equal weight would be given to both tests and an average of the 2 ratings of 900 would be considered satisfactory. The standard was arrived at from a study of laboratory results in the 3 cities during the past 5 years. There are 70 public and semi-public pools in Cincinnati, each of which is sampled at least once each week. Graphs are included showing reduction in bacterial counts and in presumptive positive *B. coli* tests in Cincinnati pool waters during past 5 years and monthly bacterial counts and *B. coli* results during 1928. **Some Features of Swimming Pool Design.** W. A. BECKER. 52–3. On the basis that 3 turnovers or recirculations through the purification system are required to purify the water in a pool, i.e., that 66, 87, and 97 percent of the impurities are removed in 1, 2, and 3 turnovers respectively, formulas have been developed for determining the maximum number of bathers permissible in a given pool and the size of pool required for a given load. The residual Cl_2 content of pool water should be from 0.2 to 0.5 p.p.m. Uniform residual Cl_2 content throughout the pool can only be maintained by distributing the chlorinated water under pressure at various points around the bottom of pool. Water of better quality than that specified in the U. S. P. H. S.

standard for drinking water can be maintained in a swimming pool. **Cross-Connections between Public and Private Water Supplies.** 54–8. Illustrated details are given of type of cross-connection permitted by Ohio Department of Health in certain instances where there is no regular use from the secondary system. Approval of such connection by local officials signifies acceptance by the city of joint responsibility with the company in the event of polluted water entering distribution system. In another type, which is permitted in order to render city supply available to a factory on short notice, connection is made by temporary insertion of a short length of flanged pipe kept on hand for the purpose. **Research on Removal of Phenolic Tastes in Water Supplies.** R. D. SCOTT. 59–60. Superchlorination experiments started in 1928 (cf. This JOURNAL, 21: 1758) have been continued, using weekly composites of raw Lake Erie water from Cleveland and raw Ohio River water from East Liverpool and from Cincinnati. Phenols, in form of ammonia still waste, were added to the samples in concentrations of from 0.002 to 1 p.p.m. In no case was chlorophenol taste noted in controls to which no phenol had been added, although several samples gave strong tastes on chlorination, which, in some instances, were apparently due to algae and in others, were suggestive of moldy straw and due probably to leaching of grass, leaves, and other vegetation. The samples were treated with various amounts of Cl_2, allowed to stand 20 hours, residual Cl_2 then determined and taste noted both before and after dechlorination with $Na_2S_2O_3$. Results are summarized in tables. In 3 sets of composites to which 0.002 p.p.m. phenol had been added, chlorophenol taste was noted after chlorination in 1 of the 3 Lake Erie samples, in all 3 from Cincinnati, but in none of the 3 from East Liverpool. Absence of taste was noted in several Ohio River samples treated with 0.01 and 0.1 p.p.m. phenol, respectively. In samples to which 1 p.p.m. phenol had been added, taste of phenol, but not of chlorophenol, was observed with Cl_2 dosages of 0.2, 0.5, 1.0, and 3.0 p.p.m.; a chlorophenol taste was, however, noted with 5.0 p.p.m., but again destroyed by 10 p.p.m. Cl_2. Chlorine application as low as 0.2 p.p.m. occasionally resulted in tastes. The average Cl_2 dosages required for destruction of chlorophenol tastes in samples to which 0.1 and 0.01 p.p.m. phenol, respectively, had been added were: Cleveland, 3.1 and 1.8 p.p.m.; East Liverpool, 6.4 and 4.5 p.p.m.; Cincinnati, 5.7 and 3.3. Data are included on residual Cl_2 content of samples from which taste had been removed after 20 hours' standing. The residual varied widely, being much the highest in the East Liverpool samples, probably owing to low pH value of the Ohio River water at this point. **Control of Phenol Tastes by Means of Increased Lime Treatment.** J. SHELDON SCOTT. 61–3. Serious tastes due to phenol pollution have been experienced at Steubenville since 1925. Prechlorination, with a dosage of 0.5–1.0 p.p.m., employed in addition to final chlorination with 0.20 p.p.m. when water is heavily polluted, results in intense chlorophenol taste. Experiments showed that addition of lime to give a basicity (normal carbonate alkalinity) of 30 p.p.m., gives removals of *B. coli* and of bacteria developing at 37° equal to prechlorination. This treatment has been employed since July, 1928, as a substitute for prechlorination when phenol pollution is present. Experience indicates that it reduces phenol concentration, it having been found that taste will not occur, regardless of the dosage of Cl_2 applied to the

filter effluent and of the amount of phenol present in the raw water when excess lime treatment is employed. Laboratory experiments with water to which ammonia still waste had been added to give phenol concentration of 0.11 p.p.m., showed reductions in phenol content of 36 to 72 percent when treated with 2 grains per gallon of alum and sufficient lime to give basicities of 13 to 65 p.p.m., respectively. The minimum residual phenol content, however, was higher than the amount required to give a marked taste in Steubenville water following chlorination. **The Taste and Odor Problem at Toledo.** R. W. FURMAN. 64–6. Taste and odor has long been a source of trouble in the Toledo water supply, which is drawn from the Maumee River. Investigations have indicated that the tastes are due to decomposing organic matter rather than to phenols. Laboratory experiments were made to determine the effects of superchlorination and of lime-soda treatment. The Maumee River water absorbs large amounts of Cl_2, 15 p.p.m. giving no residual. It was observed that 5 p.p.m. of Cl_2 and a contact period of 2½ hours were necessary to remove taste and odor. Lime-soda treatment to give 30 p.p.m. causticity removed in excess of 90 percent of taste and odor. During taste and odor periods the sedimentation basin sludge is extremely offensive, odors from dilutions of the sludge being similar to those from grass and other vegetation in state of decay. It is believed that a process combining aëration, softening, and chlorination would eliminate the difficulty. **The Ammonia-Chlorine Process as a Means for Taste Prevention and Effective Sterilization.** M. M. BRAIDECH. 67–83. It has been definitely established that the "medicinal" taste which develops periodically in chlorinated water at Cleveland, frequently following ice-floe movements in the lake, is due to industrial waste pollution. Extensive experiments have been carried out in the laboratory and in a 450,000-gallon per day experimental plant to determine effectiveness of the Cl_2-NH_3 process for preventing taste. Ammonia was applied as NH_4OH and phenol either as c.p. carbolic acid, or as ammonia still waste of known phenol content. Effectiveness of the NH_3 treatment was readily demonstrated. With application of 0.25 p.p.m. NH_3, Cl_2 dosage may be varied from 0.2 to 0.5 p.p.m. in presence of 0.1 to 0.5 p.p.m. phenol without producing taste. When, however, the Cl_2 added exceeds 0.5 p.p.m., tastes are produced, their intensity varying with the amounts of phenol and of Cl_2 added. With 0.5 p.p.m. NH_3 and 0.3–0.5 p.p.m. Cl_2, no taste occurs in presence of 1.0 p.p.m. phenol. The detention period following addition of NH_3 is apparently not important, intimate mixing prior to chlorination being all that is required. It was found that as little as 0.001 p.p.m. phenol would produce a very perceptible taste on chlorination. Extensive bacteriological tests showed that pre-ammoniation increases efficiency of chlorination. There is a lag in rate of sterilization which does not occur with Cl_2 alone, but this can be more than compensated for either by means of higher residual Cl_2 content which can be maintained without producing chlorinous tastes and odors when NH_3 is also present, or by prolonging detention period. Presence of NH_3 markedly retards Cl_2 absorption, thereby increasing the period of time over which the Cl_2 is effective, completely eliminating after growths. No more Cl_2 is required and in some cases possibly less. The present cost of sterilization with Cl_2 alone in Cleveland is 17 cents per million gallons. With anhydrous NH_3 at 15 cents per pound, the additional cost of

pre-ammoniation would range from 17 to 57 cents per million gallons. **Grading of Sand and Re-sanding the Cincinnati Filters.** CLARENCE BAHLMAN and E. B. EVANS. 84–95. Cf. This JOURNAL. A detailed discussion of methods employed in grading Ohio River sand for filter use. During the 22 years the filters had been in operation, original 30-inch depth of sand had expanded to 42 inches; effective size of sand had increased from 0.34 to 0.50 mm.; and uniformity coefficient had declined from 1.60 to 1.29. The acid-soluble incrustation amounted to 51 percent by weight of the sand. There was no indication of decreased filter efficiency as sand increased in size. The length of filter runs, however, increased almost proportionally with increase in effective size of sand. Re-sanding was necessary because loss of freeboard, which had become reduced to 10 inches, and lowered specific gravity due to incrustation, resulted in loss of sand during washing. Eighteen inches of old sand was retained in filters and 12 inches of new sand, of 0.38 mm. effective size and 1.45 uniformity coefficient added. After washing, $\frac{3}{4}$ inch of sand was removed from surface. The size of sand at various depths in the resanded filters is shown graphically. Freeboard is 26 inches and 22-inch vertical rise per minute is used in washing. Bacterial efficiency of resanded filters did not quite equal that of old filters, but difference was slight, being almost within the limits of experimental error. Under normal conditions, new filters in service 4 months or more give runs averaging 60–70 percent of those of old filters and use a maximum of 1.70 percent wash water. During a 4-day period when algae were present in the raw water in unprecedented numbers, both old and new filters were considerably affected, runs of former averaging 6.7 hours and wash water 6.2 percent, and of latter, 5 hours and 10.5 percent, respectively. Cost of the graded sand in place in the filters was $8.69 per cubic yard. Completion of Ohio River dams may cause more frequent and pronounced algae troubles and at such times it is planned to use artificial turbidity as a remedy for short filter runs. **Maintaining Chemical Balance to Resist Corrosion and Its Application to a Recent Development in Water Softening with Lime.** CHARLES P. HOOVER. 96–9. Corrosion of water pipes can best be prevented by treatment with lime to the point where $CaCO_3$ will be deposited as an impervious film. Whether a water will deposit or dissolve such a film can be determined by adding $CaCO_3$ to a sample of the water, the methyl orange alkalinity of which has been determined, stirring a few minutes, settling, filtering, and determining the resulting alkalinity. Increased alkalinity will indicate that the water was unsaturated with $CaCO_3$; decreased alkalinity, supersaturation. If the water is in chemical balance, the alkalinity will not change. This test suggests a method by which carbonate hardness may be reduced to the theoretical limit. With excess lime treatment (25 to 50 p.p.m. in excess of theoretical requirement) and recarbonation prior to filtration, carbonate hardness has averaged 30 p.p.m. at Columbus during past year and 25 p.p.m. during the last 4 months, good results being obtained even in freezing weather. The recarbonation process, however, must be very closely controlled and the filter sand grains become incrusted and cemented together with Ca and Mg compounds. Once or twice each year it is necessary to spade up the sand and crush all hard lumps, and after some years' service resanding may be necessary. The modified process suggested consists of adding 25 to 50 p.p.m. of lime in

excess of that theoretically required to combine with free and half-bound CO_2 and to precipitate Mg, settling (preferable but not essential), neutralizing excess lime with CO_2, adding large excess of $CaCO_3$, water softening sludge, or other inert finely divided material, settling, and filtering. For example a, sample of water which had been treated with excess lime and recarbonated had methyl orange alkalinity of 60, phenolphthalein alkalinity of 31, and caustic alkalinity, therefore, of 2 p.p.m. After adding 1500 p.p.m. $CaCO_3$, stirring for less than ½ minute, settling, and passing through filter paper methyl orange alkalinity was 15, phenolphthalein alkalinity 4 p.p.m., and caustic alkalinity, zero. Experiments have indicated that addition of sludge is beneficial only after $Ca(HCO_3)_2$ has been converted to $CaCO_3$, Mg to $Mg(OH)_2$, and excess $Ca(OH)_2$ to $CaCO_3$, the sludge then accelerating precipitation and acting as a stabilizing agent. It is believed that this process will not require as close supervision and that it will eliminate filtration difficulties and produce a stable product. It is estimated that a saving of more than $400,000 in operating costs could have been effected by employing this method at Columbus during the past 20 years, as less of the more expensive soda ash, would have been required owing to the more effective use of lime. **Comparison of *B. coli* Results at Ohio Filtration Plants.** THOMAS R. LATHROP. 100–4. Tabulations are given showing *B. coli* contents of raw, filtered, and disinfected waters at Ohio filtration plants during 1927 and 1928. At 16 of 25 plants listed, raw water *B. coli* content averaged higher than 500 per 100 cc. Yearly averages of *B. coli* content of chlorinated plant effluents during the 2 years were well within the limit for safe water, with exception of one plant where extremely high pollution accompanied by phenol wastes resulted in a greater Cl_2 demand than anticipated during a period of 2 or 3 days. Data given do not indicate correlation between *B. coli* indexes of the filtered waters and those of the corresponding raw waters. **Municipal Water Treatment Plants in Ohio.** 105–7. Tabulations of filtration and softening plants in state, giving population served, plant capacity, and treatments and devices (from a list of 26) employed in each case. **The Marysville Water Purification and Softening Plant.** PAUL S. ELLIOTT. 23. Brief description of new Marysville plant, treating Mill Creek water, which consists of mechanical mixing chambers providing 75 minutes detention, clarifier, carbonation chamber, and three 0.33-million-gallon per day filters.—*R. E. Thompson.*

Flood Flows. ALLEN HAZEN. *Pub. John Wiley and Sons, Inc., 1930.* 199 pp. $4.00. Loss of life and property and the suffering caused by great floods in widely separated parts of this country, and in fact throughout the world, compel general interest in the subject. The reasons why great floods occur are numerous and involve combinations of many different elements in a manner which makes the problem one of great complexity. The fact that for long periods floods of but moderate amounts occur instils in the public a false assurance of safety which results in the use of low lands along our streams for purposes of business and habitation. This use of flood channels has a dual effect, sometimes increasing the height of floods and always greatly adding to the damage that occurs when the inevitable large flood comes. This book by Mr. Hazen is the result of a long and careful study of floods of this country.

Facts as to the actual occurrence of floods for many rivers are analyzed and the results presented for use of engineers dealing with the problem. In many respects the methods used are similar to those presented by Weston E. Fuller in the Transactions of the American Society of Civil Engineers in 1914. Floods on different rivers are compared in the same way, that is, by utilizing the average of the single largest flood for each year, to obtain the so-called flood coefficient. In studying the frequency of occurrence of great floods, however, the author uses the more elaborate probability method, and with the additional data available for some fifteen years, gives frequency relations for different sections of the country. A comparison with the earlier paper shows that for the eastern part of the country, the relation is not materially different, but for the west, quite large differences are shown. Studies of the frequency of flood occurrence for many different rivers are shown in the book, but a warning is sounded as to the reliability of individual records of frequency. This is done by showing how greatly the occurrence of a single large flood has affected some of the longest available records. The author finally divides the streams of the country into either groups and gives an average frequency relation for each group. Considerable detail as to the probability methods used and tables to aid in such studies are given for the use of those making similar studies. From a restudy of the relation between the maximum rate of flood to the average rate for twenty-four hours, the author concludes that the relation established in the earlier paper holds in general for eastern streams, but is not applicable to the west. Other methods of studying flood flows which have been used or have been suggested are discussed as well as the effect of some factors, such as storage, both in lakes and in the ground, land drainage and forestry. One chapter deals with extremely heavy rainfall, showing the frequency of occurrence and the effect of the size of the area over which the rainfall is considered. An interesting chapter deals with the extraordinary floods which have occurred and which seem to exceed those to be expected, in accordance with the ordinary frequency relation. The difficulties of measurement of such floods and the probability of error in such estimates are clearly stated. The author makes it quite clear that the great damage caused by floods in recent years is due to the use of flood channels for purposes for which they are not adapted and makes many useful suggestions as to the proper use of such low land. The book is a valuable addition to flood literature, contains a large amount of useful data for many streams throughout the country and should prove of great value to those dealing with the difficult flood problem.

Hudson Bay. Surface Water Supply of United States, 1926. Pt. 5, Hudson Bay and Upper Mississippi River Basins. NATHAN C. GROVER, chief hydraulic engineer, W. A. LAMB, S. B. SOULE, J. B. SPIEGEL, H. E. GROSBACH, and H. C. BECKMAN, district engineers, 1930. Water Supply paper 625: U. S. Geological Survey.—*Arthur P. Miller.*

Missouri River. Surface Water Supply of United States, 1925. Pt. 6, Mi[illegible] River Basin. NATHAN C. GROVER, chief hydraulic engineer; W. A. L[illegible] C. G. PAULSEN, ROBERT FOLLANSBEE, J. B. SPIEGEL, H. B. KINNISON[illegible]

C. BECKMAN, district engineers. Water Supply paper 606: U. S. Geological Survey.—*Arthur P. Miller.*

Missouri River. Surface Water Supply of United States, 1926. Pt. 6, Missouri River Basin. NATHAN C. GROVER, chief hydraulic engineer, W. A. LAMB, ROBERT FOLLANSBEE, C. G. PAULSEN, J. B. SPIEGEL, and H. C. BECKMAN, district engineers. 1930. Water Supply paper 626: U. S. Geological Survey.—*Arthur P. Miller.*